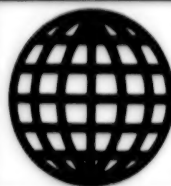


JPRS-CST-89-010

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# ***JPRS Report***

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# **Science & Technology**

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***China***

JPRS-CST-89-010

16 MAY 1989

## SCIENCE & TECHNOLOGY

### CHINA

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## SCIENCE AND TECHNOLOGY POLICY

Technology Exports for 1988 Hit U.S. \$286 Million

40080116a Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS]  
in Chinese 18 Jan 89 p 1

[Article by Li Yuan [2621 0337]]

[Text] To strengthen the overall management of its technology export, China mobilized local units and departments in creating avenues of technology exports. According to incomplete statistics, technology export contracts in 1988 totaled U.S.\$286 million.

In 1988 the technology export management departments approved 21 contracts for an amount of U.S.\$7.02 million. Out of this amount, 47.42 percent or U.S.\$3.3289 million were software exports and 59.58 percent or U.S.\$3.6911 were equipment exports. Major export industries were chemical engineering, mechanical, computer software, and agricultural. Major countries and regions were the United States, Japan, German Democratic Republic, Hungary, Australia, Federal Republic of Germany, Thailand, Bangladesh, and Hong Kong.

In 1988 provinces and municipalities in China signed 112 contracts for an amount of U.S.\$166.84 million to export technology, complete sets of equipment, and production lines. Out of this amount, 8.67 percent or U.S.\$14.46 million was for technology, and 91.33 percent or U.S.\$152.386 million was for equipment.

At the China Foreign Technology Trade Fair held in October 1988 in Shenzhen, 13 contracts totaling U.S.\$13.33 million were signed for exporting technology, sets of equipment, and production lines.

The opening up of technology export avenues is very significant to China's export commodity structure and the export of new products and technical products. Such avenues led to 161 contracts for a total of U.S.\$37.9486 million in technology product exports in 1988. Out of this amount, 108 contracts or U.S.\$26.7786 million were signed by provinces and municipalities, and 53 contracts or U.S.\$11.17 million were signed at the China Foreign Technology Trade Fair.

In 1988, besides the China Foreign Technology Trade Fair, the Technology Import and Export Bureau under the Ministry of Foreign Economic Relations & Trade also organized and supervised some general promotion activities in which U.S.\$60.765 million of sales were made. In February 1988, U.S.\$4.2 million of sales were made by the technology group in the third trade session between China and the [European] Community. In May 1988, [contracts for] U.S.\$27 million of technology exports were signed at the America Technology Trade Fair. At the Malaysia International Exposition held in August, U.S.\$600,000 of business was done. In November the Philippines Textile and Clothing Machinery and Technology Exposition brought in U.S.\$125,000. At the 63rd Guangzhou Trade Show (Spring 1988 meeting), the technology section did U.S.\$13.20 million of export business, and at the 64th Guangzhou Trade Show (Fall 1988 meeting) U.S.\$15.64 million of technology export business was done.

State of Science, Technology Legislation Reviewed

40080142 Beijing KEJI RIBAO in Chinese 23 Jan 89 p 3

[Article by Luo Wen]

[Text] Over the past 10 years, the establishment of China's legal system has recovered and made progress. The development of science and technology legislation has been particularly rapid. A new group of legal norms--the S&T law sector--is appearing in China's socialist legal system, indicating that the age in which China will apply law to the promotion and management of S&T undertakings has arrived.

At present, except for those principles and regulations in the constitution governing development of S&T, there exists those patent laws, contract legislation, statistical statutes, measurement laws and other specialized S&T legislation enacted by the National People's Congress and its standing committee. In addition, a great many S&T legal standards are contained in legislation pertaining to environmental protection, cultural protection, food hygiene, marine transportation, public health quarantine, medical policies and all types of resource legislation. Furthermore, the State Council and its affiliated organizations have also issued nearly 300 administrative laws, rules, and regulations bearing on S&T. Each province, autonomous region and self-governing municipality has also formulated a mass of local S&T laws and regulations.

The administrative laws, rules, and regulations issued by the State Council and its affiliated organizations generally can be divided into the following several categories:

1. Promoting Reform of the S&T System.

In March 1985, the Chinese Communist Party Central Committee came out with the "Decision Regarding Reform of the Scientific and Technological System" and established the strategic policy which holds that "economic construction must depend upon S&T progress, and S&T work must be geared toward economic construction." At the end of that same year the State Council established technology policies for 12 areas including energy and transportation. In the following year, strategic planning for S&T development was completed.



In order to realize the state S&T development strategy, execute related policies and complete the task of reforming the S&T system, the State Council issued in succession "Temporary Regulations Regarding Management of Allocations for Science and Technology" (23 January 1986), "Temporary Regulations Regarding Expansion of Science and Technology Research Organization Autonomy" (19 April 1986), "Some Regulations Concerned with Further Promoting S&T System Reform" (20 January 1987), "Regulations Regarding Promoting the Establishment of Scientific Research and Design Units in Large and Mid-sized Industrial Enterprises" (20 January 1987) and other laws and regulations.

Meanwhile, relevant organizations of the State Council also issued corresponding rules and regulations. For example, the "Notification Regarding the Transfer of Funding Quotas for Scientific Research Undertakings" (6 March 1986) jointly issued by the State Science and Technology Commission and the Ministry of Finance, the "Temporary Regulations Regarding Management of Expenditures for Scientific Undertakings," the "Notification Regarding the Problem of Award Taxes Levied Against Scientific Research Organizations" (2 March 1987), and the "Temporary Regulations Regarding Categorization of Scientific Research Organizations" (24 March 1986) issued by the State Science and Technology Commission.

These laws and regulations are all centered on regulating reform of the methods of managing allocations for S&T, the opening-up of technological markets, the expansion of the autonomy of scientific research organizations, the promotion of the unification of scientific research with production and the strengthening of the technological absorption and development capacity of enterprises. They are playing a major role in leading S&T toward a new system and in renovation.

## 2. Management of S&T Research Organizations and S&T Corporations.

As of the end of 1986, China had 5271 S&T research and development organizations belonging to governmental departments above the county level. These had a total of 324,760 scientists and engineers. Nationwide there were over 126,000 S&T corporations of all types employing over 8.8 million people.

Managing such a large number of scientific research organizations and corporations, each on a different level, is both very important and very complex. S&T organizational laws relevant to this area are still being drafted. Those presently followed primarily include the "Trial Regulations of the Chinese Academy of Sciences" (18 May 1981) and the "Regulations for Scientific and Technological Associations in China" (27 June 1986). The "Examination and Approval Methods for the Establishment and Modification of Natural Science Research Organizations" (17 March 1983) set regulations for the examination and approval problem in the establishment or modification of scientific research organizations.

## 3. The Cultivation and Management of S&T Personnel.

On 23 April 1981, the office of the Central Committee of the Communist Party of China and the office of the State Council jointly issued the "Trial Regulations for Management of Scientific and Technical Cadres," which regulated respectively the scope of S&T cadre management; assignment and utilization; training, education and evaluation; and promotion, rewards and penalties.

On 13 July 1983, the State Council issued "Some Regulations Regarding the Rational Movement of S&T Personnel" to address the irrational situation which exists with respect to the distribution and structure of China's S&T contingent. Twenty-three measures were stipulated to encourage the rational mobility of S&T personnel. Its general directions of movement are from the cities toward rural areas and from large cities toward small and mid-sized towns, from central regions toward remote areas, and from those sectors and units with a surplus of S&T personnel toward those sectors and units weak in S&T capacity and which are in urgent need of strengthening.

On 5 July 1985, the State Council ratified and promulgated a report by the State Science and Technology Commission, the Ministry of Education and the Chinese Academy of Sciences concerning pilot-project centers for post-doctoral scientific research and established a post-doctoral research system.

On 18 February 1986, the State Council came out with "Regulations Regarding Implementation of the Appointment System for Professional Technology Positions," which regulates the content of the appointment system and the creation of positions, the qualifications for positions, the determination of proportions in the job structure and wages, job evaluation, hiring and appointment, concurrent posts, waiting for appointments, and the separation and retirement of professional technical personnel. Moreover, these regulations nullified previous regulations issued by the State Council or affiliated departments regarding the assessment of professional titles.

Soon thereafter, the Chinese Academy of Sciences formulated "Trial Regulations for the Position of Natural Science Research Personnel" (1 March 1986), which specifically stipulated the professional titles of natural science research personnel, the conditions for holding posts, responsibilities, compensation and evaluation procedures. These regulations are being applied in top-level academies and institutes. During March and April of this year, "Trial Regulations for the Post of Instructor at Institutes of Higher Education," "Trial Regulations for the Post of Experimental Technician," "Trial Regulations for the Post of Public Health Technician," and the Chinese Academy of Social Sciences' "Trial Regulations for the Post of Researcher" also emerged one after another. The five sets of regulations listed above and the "Views on Implementation" of each are all important administrative rules and regulations of major significance to the management of China's 14 million existing professional technical personnel and to the protection of their personal benefit. Additionally, the "Temporary Regulations Regarding the Separation and Retirement of Professional Technical Personnel" (19 September 1986) is among the important regulatory documents in this area.

#### 4. Incentives for S&T Accomplishment.

Since 1984 the State Council revised or drafted the following regulations for rewarding and encouraging invention and S&T accomplishment: The "Natural Science Incentive Regulations of the People's Republic of China" (issued by the State Council on 21 November 1979 and revised by the State Council on 25 April 1984), the "Regulations of the People's Republic of China on Incentives for Invention" (issued by the State Council on 28 December 1978 and revised by the State Council on 25 April 1984), the "Scientific and Technological Progress Incentive Regulations of the People's Republic of China"



(issued by the State Council on 28 September 1984), and the "Rationalization Proposals and Technological Progress Incentive Regulations" (issued by the State Council on 16 March 1982 and revised by the State Council on 4 June 1986).

In addition, the State Science and Technology Commission issued the "National Spark Incentive Measures" on 2 July 1987 and the National Examination Committee for Science Awards issued the "Detailed Implementation Principles for Incentives for Scientific and Technological Progress of the People's Republic of China (Trial)" on 15 December 1986.

#### 5. The Management and Transferral of Possession of S&T Accomplishments.

On 10 January 1985, the State Council issued the "Temporary Regulations Regarding Transferring the Possession of Technology." In order to facilitate smooth implementation of the "Patent Law" and the "Technology Contract Law," the State Council ratified and the State Patent Bureau and the State Science and Technology Commission separately issued the "Detailed Principles of Implementation for the Patent Laws of the People's Republic of China" and the "Detailed Principles of Implementation for the Technology Contract Law of the People's Republic of China."

Also, the State Council and its affiliated organizations continue to formulate corresponding rules and regulations regarding specialized issues such as the "Regulations for Management of Supervision of Civilian Nuclear Facility Safety" and its four complimentary safety regulations, the "Temporary Regulations Regarding Protection of the Monitoring Environment of Seismic Stations," and the "Regulations Regarding Management of the Accomplishments of Scientific and Technological Research."

Besides the five areas above, the State Council and its affiliated organizations have also formulated some methods and regulations pertaining to the supply and management of scientific research materials, S&T exchanges with foreign countries and the protection of secrets, and S&T record-keeping and information exchange.

In general, over the past 10 years, the National People's Congress and its standing committee, the State Council and its affiliated organizations, as well as local and national organizations, have all paid particular attention to the field of S&T legislation. These laws, regulations, and rules possessing different legal status and effect are increasingly coming together to form a distinctively Chinese family of S&T legislation. Naturally, China's fledgling S&T legislation is still in need of coordination and perfection and the establishment of China's S&T legal system still awaits further strengthening.

Design, Analysis of Optimal Guidance Law for BTT-90 Missile

40090046a Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, Jan 89 pp 10-18

[English abstract of article by Yang Di [1728 3321], et al., of Harbin  
Institute of Technology]

[Text] In this paper, a kind of guidance law for the BTT-90 missile is designed and analyzed. After that, it is applied to the 6-DOF trajectory simulation of the BTT-90 missile. The satisfactory simulation results indicate that this guidance law has good engineering value. This guidance law has been derived through the optimal control theory. It is simple in form and explicit in physical meaning. The simulation results of the theoretical particle trajectory prove that this guidance law is reasonable and realizable for BTT missiles.

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# Higher Order Linearization Method of Nonlinear Systems, Its Application to Second Order Perturbation Guidance

40090046b Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 1, Jan 89 pp 33-39

[English abstract of article by Jin Liang [6855 2733] of Beijing Institute of Control Engineering]

[Text] This paper has derived a higher order linear approximation of nonlinear systems related to the nominal state and nominal control. The method for a nonlinear system to be approximated to a higher order by the transformation of a linear system is obtained by using the ideals of nonlinear coordinate change and nonlinear state feedback. The formulas for calculating the coefficients of higher order terms are given. Then, the use of this technique in designing second order perturbation guidance equations is suggested.

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**Analysis of Aeroelastic Divergence for Slender Flight Vehicles**

40090046c Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, Jan 89 pp 46-50

[English abstract of article by Chen Wenjun [7115 2429 0193] of Beijing  
Precision Machinery Overall Design]

[Text] This paper generalizes the aeroelastic divergence analysis of a rocket to which the two point aerodynamic lifts discussed in the reference have been applied in two senses, extending the number of point aerodynamic lifts on a slender flight vehicle from 2 to  $N$  (arbitrary positive integral), and includes the effect of aerodynamic interference omitted from the reference.

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## Kind of Predictive Intercept for Terminal Guidance

40090046d Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, Jan 89 pp 51-60

[English abstract of article by Jiang Yuxian [1203 3768 2009] of Beijing  
Institute of Aeronautics and Astronautics]

[Text] This paper presents a new terminal guidance law for predictive intercept. If predicted collision courses are replaced with equivalent collision courses, this method only needs to measure the rotation rate of the line-of-sight and, therefore, the measured parameters are reduced. This paper also presents a new approach to the designing of asymptotic guidance systems when external disturbances exist. By using it to design these guidance systems, they can widen the attack zone of the missiles to an egg-shape space and make the principle miss distances approach zero. In order to demonstrate the above conclusions, the simulation results for missile trajectories are given.

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Application of Sensitivity, Robust Stability Theory to Missile Launching  
Decision

40090046e Beijing YUHAN XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, Jan 89 pp 61-68

[English abstract of article by Deng Fanglin [6772 2455 2651], et al., of the  
Second Artillery Engineering College]

[Text] The dynamic characteristics of a multi-variable system under parameter perturbations are analyzed by system sensitivity theory in this paper. The critical regions of influence of certain parameters on the system dynamic performances, their mutual deviation compensations and their optimum combinations are studied to improve the robustness of the system. This paper is intended to give a simplified and practical method of providing quantitative information to the commander on spot to make decisions regarding the system when certain parameters are beyond the permissible limits.

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# Stability of Thin Laminated Circular Cylindrical Shells Containing Elastic Core

40090046f Beijing YUHANG XUEBAO [JOURNAL OF CHINESE SOCIETY OF ASTRONAUTICS]  
in Chinese No 1, Jan 89 pp 91-98

[English abstract of article by Zhu Runxiang [4555 3387 4382], et al., of  
Northwestern Polytechnical University]

[Text] The stability of thin laminated circular cylindrical shells with elastic cores under uniform axial compression, lateral pressure and hydrostatic pressure is analyzed. The Galerkin-difference method is used to simplify the modified Donnell equation into linear equations. Then, according to the stability criterion, the critical loads can be found. Some examples are presented. The results show that the material behavior of the core and the boundary conditions of the shell have a great effect on the stability. The method appears to be worth recommending, especially when designing solid propellants.

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**HQ-61: Chinese-Developed Surface-to-Air Missile**

40080132 Beijing JIANCHUAN ZHISHI [NAVAL AND MERCHANT SHIPS] in Chinese No 1, 8 Jan 89 pp 4-5

[Article by Tang Zhongfan [0781 6988 5672]]

[Text] In the third Asian Aerospace Exhibit held in Singapore from 15-18 January 1986, the following Chinese-built aerospace products were on display: the "Long March 2" and "Long March 3" launch vehicles, the experimental communications satellite, and the satellite television antenna; a number of Chinese-built missiles were also on display: the "HN-5" shoulder-launched air-defense missile, the "HQ-2J" surface-to-air missile, the "HQ-61" ship/surface-to-air missile, the "HY-2" ship-to-ship missile, the "HY-4" medium-range anti-ship missile, the "C-601" air-to-ship missile, the "C-101" supersonic anti-ship missile, and the "C-801" multi-purpose missile. Of these, the "HQ-61," the "HN-5A" and the "HY-4" missiles were introduced for sale to other countries for the first time.

The "HQ-61" missile is a Chinese-built high-performance air-defense missile; it is available in two different models: the ship-to-air model and the surface-to-air model. The "HQ-61" is an all-weather missile designed to intercept targets flying at medium or low altitudes. Its performance is considered superior in terms of guidance accuracy, kill power, reliability and ease of operation.

The missile is 3.99 m long and 0.286 m diameter; its maximum wing span is 1.166 m, and the launch weight is 300 kg. Its maximum velocity is three times the speed of sound, its maximum effective range (in the horizontal direction) is 10 km, and its maximum effective altitude is 8 km.

**Missile Construction**

The "HQ-61" missile has five major segments: (1) the missile body, the wing and the tail fin; (2) the guidance unit; (3) the warhead and fuse; (4) the autopilot and onboard power supply; and (5) the solid-propellant rocket engine.



The missile body is a slender cylinder with a conical nose section. Located in the mid section of the body is a movable wing operated by a hydraulic servo-mechanism. The wing and the tail fin are arranged in a "+-x" configuration. The title figure shows the profile of the missile.

The guidance unit is located in the nose section (see title figure); it is a continuous-wave semi-active radar guidance unit which provides very high guidance accuracy and has strong interference-rejection capability.



At the tail section of the missile is a solid-propellant rocket engine (Figure 1). The combustion chamber of the engine is filled with high-performance, high-specific-impulse propellant which can accelerate the "HQ-61" to a maximum velocity of Mach 3.

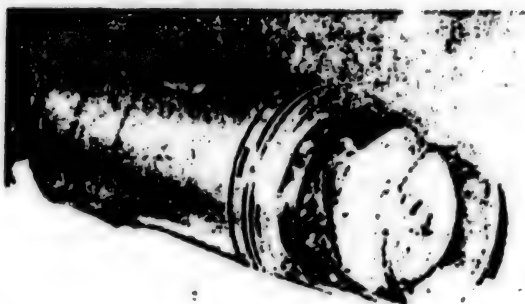


Figure 1. Solid Rocket Engine

In front of the engine is a chain-type fragmentation warhead which has very high kill power. The fuse for the warhead is located behind the guidance unit; it is designed to detonate the warhead at a preset time. The fuse is highly reliable and has good interferences-rejection capability which precludes inadvertent detonation due to external disturbances. The warhead weighs 40 kg.

The onboard power source and the autopilot are located behind the fuse. The power source provides both a.c. and d.c. current to the missile, and is driven by a gas turbine generator. The autopilot has a high degree of sensitivity, accuracy and reliability. During its flight from the launcher to the target, the missile is controlled by the autopilot at all times.

#### Weapon System and Operating Procedure

The "HQ-61" ship-to-air weapon system has seven major segments: (1) the "HQ-61" ship-to-air missile, (2) the launch system, (3) the missile launch chamber and the loading mechanism, (4) the fire-control system, (5) the control and launch platform, (6) the tracking radar, and (7) the target indication radar.

Depending on the air defense requirement, one or more launchers can be installed on the deck of a ship. The launcher consists of a double-rail structure which can be rotated. Figure 2 shows two "HQ-61" missiles loaded in the launcher on the ship deck; it also shows two radar antennas.

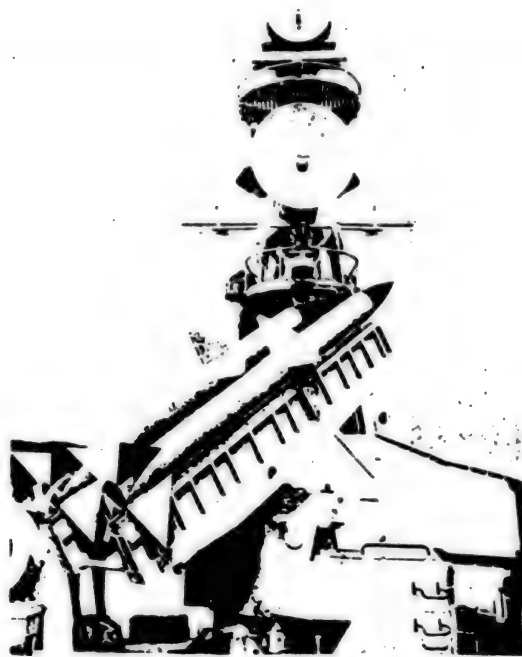


Figure 2. "HQ-61" on a Ship

When the ship is in an alert or combat condition, the target indication radar is activated. If a target or group of targets is detected during the search operation, the TI radar sends the information to the fire-control system. After analyzing the data, the fire-control system makes a decision as to which target is to be attacked, and sends the target information to the tracking radar and the launch system to aim at the target. When the target enters the attack zone, the operator pushes the launch button on the control panel, which ignites the rocket engine, and the missile heads toward the target.

During flight, the "HQ-61" receives two pieces of information which would allow the missile to guide itself toward the target and destroy it: the information on the missile itself transmitted from the tracking radar, and the information on the target based on target returns received by the tracking radar (Figure 3).

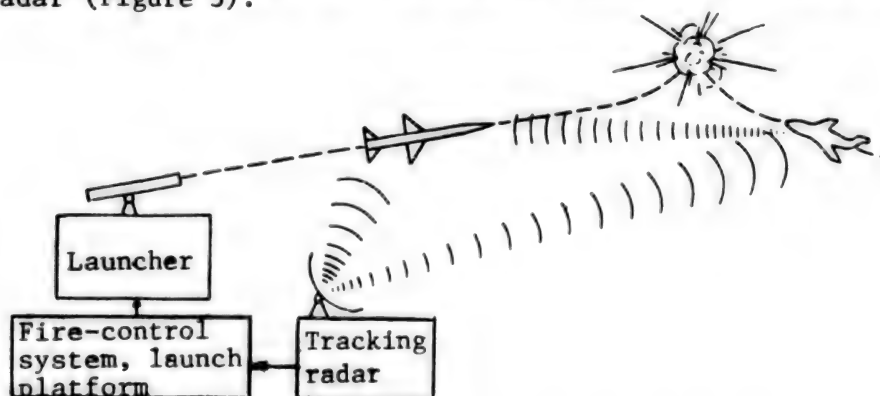


Figure 3. Schematic Diagram of Missile Operation

#### New Rocket Base in Northwest Hainan Detailed

40080141 Beijing XIANDAIHUA [MODERNIZATION] in Chinese No 2, Feb 89 pp 10-11

[Article by Li Xiguang [2621 1585 0342], Liu Maosheng [0491 5399 0524]]

[Text] In a region called Fuke located in the northwest corner of Hainan Island, the terrain consists of lush rolling hills, the climate is subtropical, and the inhabitants are members of the small Li ethnic group. As strange as it may seem, this is the launch site for China's first sounding rocket used for scientific research.

#### A Mysterious Launch Site

The tall antennas, the rotating radars and the white buildings look like a ship anchored in a sea of green trees on Hainan Island. In December 1988, the place was busy with numerous activities: military trucks, passenger cars, jeeps, radar vehicles, scientists and technicians in white clothes, and officers and soldiers in yellow uniforms went in and out of the base, creating an atmosphere of mystery. On 19 December, Chinese space scientists successfully conducted the first launch test of a sounding rocket.

On the eve of the test, in an attempt to find out the secret of the sounding rocket, this reporter obtained permission to enter the launch site.

The launch site is located on a piece of uninhabited land 10 km from Beibu wan and 70 km from the nearest town. According to officials at the base, the area affected by the launch is a 100-km radius wedge-shaped region extending into the ocean.

Currently, a facility with the capability of launching rockets carrying 30-kg payloads to an altitude of 120 km has been completed. This facility includes an underground control room, a launch field, a storage warehouse for rockets and combustibles, a rocket assembly and test chamber, a nosecone assembly and test chamber, an integrated test chamber, a remote control and data processing station, a radar tracking and positioning station, a support/maintenance room, and living quarters for 100 base personnel. An integrated ground-based observation station with modern equipment and observation instruments is under construction at a port 200 km away. The second phase

of the construction project will be carried out during the "Eighth 5-Year Plan" period; when completed, the new facility will have the capability of launching sounding rockets to an altitude of 300 km.

From a distance, the first thing that comes into view is the integrated laboratory building with antennas protruding from its rooftop. Three kilometers west of the laboratory building, this reporter climbed a hill to reach the spacious and well-lighted rocket assembly and test facility. This is a gray concrete structure set apart from the other buildings. In the middle of this facility is a mobile rocket launch tower; four milk-white colored rocket heads stand side by side next to the launch tower. The facility is guarded by several uniformed soldiers around the clock.

Continuing west through 500 m of open space, this reporter reached the launch site. The launch control center is located in an underground bunker 200 m from the launch field. Here, one can see multi-colored buttons and switches which are used to control rocket ignition. Scientists and technicians are busily engaged in pre-launch check-outs and tests.

#### The Need for Data Collection in Space

The base commander and Director of the Chinese Academy of Sciences Space Center, Sun Chuanli, explained to this reporter the reason for launching sounding rockets.

"The development of satellites and space planes did not eliminate the need for sounding rockets in space science research. Sounding rockets are the only means of collecting data at an altitude above sounding balloons and below satellites (30-200 km). They are highly mobile, relatively inexpensive, and can be launched either simultaneously from different stations or successively from a single station; they can also provide time and spatial resolution which are beyond the capability of satellites. They are the essential tool for studying high-altitude atmospheric motion and cosmic phenomena (e.g., solar eclipse, polar light, and sudden rise in temperature of the stratosphere during winter)."

As an orbit specialist who was responsible for the orbit plan of China's first satellite, the "Dong Fang Hong-1," commander Sun briefly discussed the important role of the Hainan rocket base:

--To provide real-time measurements and standard atmospheric data in support of flight tests of launch vehicles and re-entry tests and retrievals of satellites. In the design of missiles and satellites, orbit calculations, aerodynamic heating and load calculations and error analysis depend directly on atmospheric parameters; specifically, atmospheric data below 200 km are required for these calculations. Prior to the completion of the Hainan rocket base, standard atmospheric information below 200 km was unavailable because China did not have the capability to collect data at 200 km.

--To investigate the structure of the ionosphere and to study the phenomenon of sudden disturbances in the ionosphere using sounding rockets. This information would be valuable for communications and navigation.

--To conduct preliminary tests of satellite instruments at a relatively low cost; these tests not only produce useful scientific information but also provide the necessary data for improving instrument design.

--To conduct experiments in the fields of material science and space processing under micro-gravity conditions.

--To provide atmospheric information in the stratosphere and the mesosphere to support weather studies. These include the study of atmospheric structure and the variation of atmospheric parameters with altitude, season, and latitude; the study of coupling between the altosphere and the troposphere; and the study of the relationship between the circulations of the upper and lower atmosphere.

--To compare or supplement the atmospheric data obtained by satellite remote sensors and ground equipment (e.g., laser radars, UHF doppler radars).

The research scientist and official in charge of rocket development, Yang Junwen, was the first one to arrive in Hainan to select the launch site. According to Yang, sounding rockets are widely used by other countries involved in space research; specifically, they are used to study the atmospheric structure in the mesosphere and the altosphere, the atmospheric wind field, the atmospheric composition, the electron density in the ionosphere, the electron temperature, the electric field, the vertical movement of ionized particles, as well as ultra-violet radiation, X-ray and high-energy particle radiation, and infrared radiation. The current research activities in space science are concentrated around the two polar regions and the equator. Scientists from West Germany, the United States and Japan have suggested a joint sounding-rocket experiment at Hainan Island. The uniquely Chinese character of the Hainan rocket base is likely to attract an increasing number of foreign scientists to participate in cooperative research projects.

#### First Sounding Rocket Test Was a Success

The first test conducted at the Hainan rocket base used a solid rocket called the "Weaver Girl-1," which was developed jointly by the Defense Science and Technology University and the Space Center of the Chinese Academy of Sciences. This new rocket equipped with a ring-shaped booster is the first sounding rocket of a series currently being developed; this test was the first time the rocket had ever been used.

At 7:00 am on 19 December, sensors and instruments were loaded into the sounding rocket. Half an hour later, the rocket was moved to the launch field and erected onto the launch tower, pointing toward the sky. Scientists and technicians around the launch tower were all waiting for



the arrival of this exciting event with great expectation. At this point, a red sounding balloon was released into the air, and calculations of wind velocity and wind direction were carried out to determine the launch azimuth of the rocket.

Ten minutes prior to launch, the ignition cable was connected to the tail section of the rocket. At the same time, wind velocity and wind direction reports were received at one-minute intervals to assist the commander in selecting the optimum launch time. The status and conditions of different segments of the launch system were continuously being reported to the launch control center 200 m from the launch field. The atmosphere on the launch field was becoming increasingly tense.

Finally, the director of the control room who is also the assistant chief designer of the "Weaver Girl-1" rocket, Gang Cuxiong, issued the command: "One minute to go!" A key was inserted into the control panel to turn on the power while Mr Gang continued the count-down: "9, 8, 7, 6, ...." The launch field remained silent; everyone's sight was focused on the distant launch pad.

At 9 hours, 8 minutes and 43 seconds, the "launch" command was issued, and in a cloud of flame and smoke, the rocket lifted off the ground; shortly after, the "Weaver Girl-1" raced toward the sky, leaving a streak of white smoke trailing behind.

Reports on the conditions of the rocket were being continually sent back to the control room from the tracking station: "rocket operation normal," "payload-rocket separation," "parachute deployment successful." Five minutes later, the rocket body splashed down in the pre-designated region of the north bay. The data collection and processing system printed out the first set of data on the mesosphere. Two and half hours later, the sensors and measuring instruments returned to earth. During the 2-1/2 hours of drifting at high altitudes, the instruments transmitted 100,000 sets of atmospheric data on the mesosphere, all of which were received by the ground tracking system; 70,000 sets of the data were printed out by the computer as they were collected.

Pleased with the result of this test, director Sun Chuanli made the following remarks: "The success of China's first sounding-rocket test has provided the Chinese scientific community with direct atmospheric data in the mesosphere over the low-latitude and equatorial region. This is a major contribution in terms of establishing China's own data base on the space environment and supporting China's atmospheric research program; it is also a significant event in terms of promoting international cooperation."

## Conductive Polyacene-Carbon Fiber Composites

40080119 Harbin HARBIN GONGYE DAXUE XUEBAO [JOURNAL OF HARBIN INSTITUTE OF TECHNOLOGY] in Chinese No 6, Dec 88 (manuscript received Apr 88) pp 67-72

[Article by Wei Yuezhen [7614 2588 6297], Wu Shaobing [0702 4801 0365], and Sun Qiang [1327 1730] of the Applied Chemistry Department, Harbin Institute of Technology, and Zhao Xiaojiang [6392 2556 3068] and Wang Fosong [3769 0154 2646] of the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences: "A Study of Conductive Polyacene-Carbon Fiber Composites"; project supported by the National Natural Science Foundation]

[Text] This paper discusses the electrical, electrochemical and mechanical properties of carbon-fiber composites of polyacene and porous polyacene. Experimental results show that carbon-fiber composites of polyacene and porous polyacene not only have good electrical and electrochemical characteristics, but also possess good mechanical properties.

### Introduction

Polyacene (PM) is a polymer with good electrical conductance which is prepared from pyrolysis of phenolic resin. Several studies<sup>1-4</sup> have been done in this area. However, the mechanical strength of polyacene is low and it is also brittle. In this paper, composites of polyacene carbon fiber (PCC) and porous polyacene carbon fiber (PPCC) are studied. These two materials have been prepared, their structures are analyzed, and their electrical, electrochemical and mechanical properties are studied.

### I. Experimental

#### 1. Preparation of Materials and Investigation of Structures and Properties

Thermoset phenolic resin, polyacrylonitrile fiber and zinc chloride<sup>4</sup> were used as raw materials to prepare polyacene, polyacene carbon fiber and porous polyacene carbon fiber composites of various degrees of carbonization and pyrolyzation at different pyrolysis temperatures (PT) between 400-800°C. A comparison of mechanical strength and electrical conductivity was performed. X-ray diffraction and scanning electron microscopy (SEM) were used to analyze the structure and morphology of these materials.



## 2. Electrical Conductivity of Iodine-Doped Materials

Materials prepared at different pyrolysis temperatures were soaked in an iodine-saturated heptane solution for 24 hours at 20°C. The dopant level and electrical conductivity of each material were determined.

## 3. Electrochemical Characteristics

An N-type or P-type cell was put together using the pyrolyzed material as the positive electrode and lithium as the negative electrode in tetrahydrofuran (THF) or propylene carbonate (PC) with 1 M [molar] lithium perchlorate ( $\text{LiClO}_4$ ) to study its electrochemical properties, stability and temperature characteristics.

## II. Results and Discussion

### 1. Dependence of Structure and Characteristics on Pyrolysis Temperature

The intrinsic electrical conductivity of the polyacene material varies with the pyrolysis temperature. The data is shown in Table 1. The mechanical properties of four types of polyacene materials prepared at the same pyrolysis temperature were determined and the results are shown in Table 2.

Table 1. Dependence of Electrical Conductivity on Pyrolysis Temperature for Intrinsic and Doped Polyacene Materials

Temperature (°C)			500	600	660	750
Material						
Conductivity ( $\text{s} \cdot \text{cm}^{-1}$ )	PM	p <sup>1*</sup>	$<10^{-6}$	$4.0 \times 10^{-6}$	$1.7 \times 10^{-2}$	$1.4 \times 10^1$
		d <sup>2*</sup>	$<10^{-6}$	$6.6 \times 10^{-3}$	$2.6 \times 10^0$	$3.8 \times 10^1$
	PCC	p	$<10^{-6}$	$6.4 \times 10^{-6}$	$8.5 \times 10^{-2}$	$5.8 \times 10^1$
		d	$1.1 \times 10^{-6}$	$2.1 \times 10^{-2}$	$8.7 \times 10^0$	$7.1 \times 10^1$
	PPCC	p	$6.4 \times 10^{-5}$	$4.6 \times 10^{-3}$	$6.3 \times 10^{-2}$	$2.5 \times 10^0$
		d	$8.3 \times 10^{-2}$	$6.3 \times 10^{-1}$	$3.4 \times 10^0$	$6.3 \times 10^0$

1\*--intrinsic material

2\*--material doped in iodine solution in heptane, dopant level shown in Figure 4

Table 2. Density and Mechanical Strength of Four Types of Materials

Properties Name	Density (g/cm <sup>3</sup> )	Tensile strength (kg/cm <sup>2</sup> )	Impact strength (kgcm/cm <sup>2</sup> )
PM*	1.26	186.3	9.6
PCC	0.96	824.4	159.8
PPM	0.23	16.9	4.8
PPCC	0.38	120.5	28.3

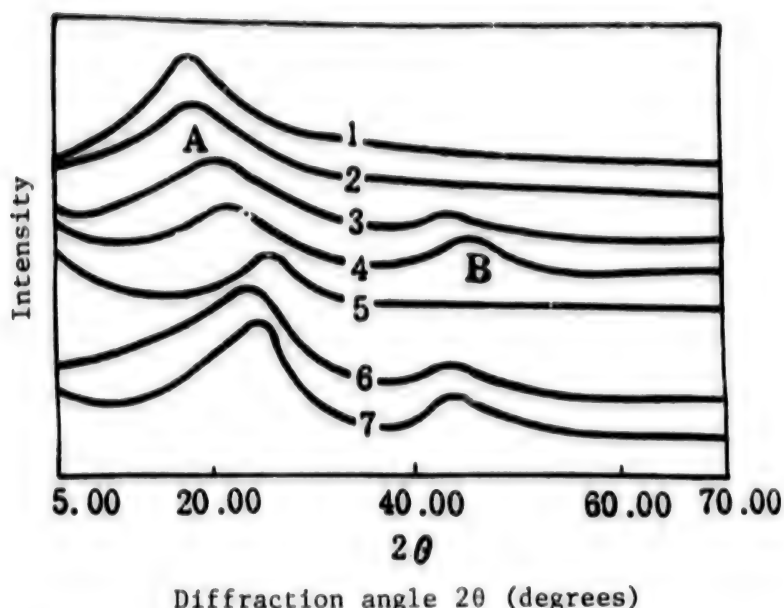
\*Obtained at same PT = 630°C)

From Tables 1 and 2 we can see that the intrinsic conductivity increases with rising pyrolysis temperature. At the same pyrolysis temperature, PCC and PPCC have better intrinsic electrical conductivity and more desirable mechanical properties. In order to explain these phenomena, we used X-ray diffraction and SEM to examine these specimens. Figure 1 shows their X-ray diffraction patterns. Figures 2 and 3 [not reproduced] are the SEM photographs showing cross-sections of PCC and PPCC. Based on diffraction patterns 1 to 4 shown in Figure 1, the diffraction angle ( $2\theta$ ) of peak A increases gradually with rising pyrolysis temperature. When the diffraction angle ( $2\theta$ ) is between 41 to 46 degrees, a new diffraction peak B begins to appear. This indicates that the mean distance between benzene rings is shortened to form the polyacene structure with rising pyrolysis temperature,<sup>3</sup> resulting in higher intrinsic electrical conductivity.

A comparison of diffraction patterns 3 and 6 in Figure 1 shows that, with the exception of peak A, there is essentially no difference. The difference in diffraction peak A might be due to the superposition of the diffraction peak A of the carbon fiber (see diffraction 5) and that of polyacene. Therefore, the fact that polyacene carbon fiber composites are more electrically conductive than polyacene itself might be because some carbon fibers are involved in the process. (See Figure 2)

Based on diffraction patterns 6 and 7 in Figure 1, the diffraction angle  $2\theta$  of peak A is 24 degrees for the former and 25.5 degrees for the latter. A comparison of diffraction peaks shows that the peak intensity of the latter is higher than that of the former. Thus, at the same pyrolysis temperature (PT is 600°C), the intrinsic electrical conductivity of PPCC is higher than that of PCC.

From the micrographs shown in Figures 2 and 3 we can see that some carbon fibers are bonded to the matrix which serves the function of conducting electricity and distributing charge and stress. Therefore, PCC and PPCC have better electrical and mechanical characteristics than PM and PPM.



- 1: Solidified FP resin.
- 2: Polyacene materials pyrolyzed at 400°C.
- 3: Polyacene materials pyrolyzed at 600°C.
- 4: Polyacene materials pyrolyzed at 750°C.
- 5: Carbon fiber.
- 6: Polyacene carbon fiber composite materials pyrolyzed at 600°C.
- 7: Porous polyacene carbon fiber composite materials pyrolyzed at 600°C.

Figure 1. X-Ray Diffraction Patterns of Polyacene-Carbon Fiber Composites Pyrolyzed at Different Temperatures

## 2. Dependence of Iodine Level and Electrical Conductivity on Pyrolysis Temperature and Structure

Polyacene materials pyrolyzed at different temperatures were doped with iodine in heptane. The results are shown in Figure 4. From Figure 4 we can see that the dopant level goes up with rising pyrolysis temperature. This may be related to the polyacene structure. With increasing pyrolysis temperature, some polyacene structures continue to form. At the same pyrolysis temperature, the iodine levels in PCC and PPCC are higher than that in PM. This may be due to the high surface area of the composites.

Table 1 shows that the electrical conductivity of all three polyacene materials increases significantly after iodine doping. The change in electrical conductivity is significant at low temperatures and small at high temperatures, as reported in the literature.<sup>2</sup>

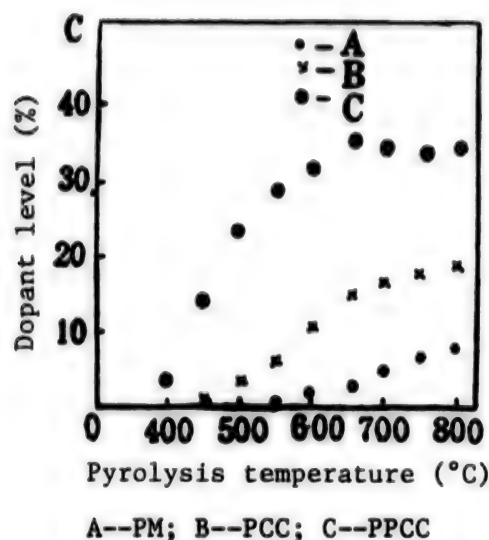


Figure 4. Dependence of Iodine Doping Upon Pyrolysis Temperature

### 3. Electrochemical Characteristics of Polyacene Materials

#### (1) Electrochemical Properties of N- and P-Type Doping

Three types of polyacene materials prepared at the same pyrolysis temperature were used as positive electrodes of electrochemical cells to determine their electrochemical characteristics. The results are shown in Table 3. Based on Table 3, the two composites have higher specific capacity, specific energy and Coulombic efficiency. This may be due to the bonding between carbon fibers and the substrate which plays a role in the conduction and distribution of charges. In addition, the porosity also improves the electrochemical property of the electrode. Furthermore, the N-type electrochemical characteristics of these three electrode materials are better than the P-type electrochemical characteristics.

#### (2) Stability of N- and P-Type Electrochemical Doping of PPCC

Cells made of electrochemically doped P- and N-type PPCC electrodes and lithium in propylene carbonate electrolyte with lithium perchlorate were prepared. The specific capacities are shown in Table 4, which indicates that the N-type cell has better stability than the P-type cell.

#### (3) Temperature Characteristics of Electrochemically Doped N- and P-Type PPCC

The temperature characteristics of the PPCC positive electrode are shown in Table 5. Based on Table 5, the electrochemical properties of this cell are better at high temperature than at low temperature. This may be due to the fact that it is easier to dope PPCC at high temperature and the viscosity of the electrolyte is decreased.

Table 3. Electrochemical Characteristics of Different Electrode Materials<sup>4\*</sup>

Material		PM	PCC	PPCC
Cell parameters				
PT(°C) <sup>1*</sup>		660	630	500
Discharge current density (per cm <sup>2</sup> )	P <sup>2*</sup>	50μA	50μA	0.1mA
	N <sup>3*</sup>	50μA	0.1μA	0.2mA
Specific capacity (Ah/kg)	P	—	18.6	42.5
	N	13.3	92.5	158.4
Specific energy (Wh/kg)	P	—	62.9	148.8
	N	14.6	112.8	266.1
Coulombic efficiency (%)	P	—	80.3	84.6
	N	61%	91.1	98.4

1\*--Best cell performance is obtained at this pyrolysis temperature.

2\*--Use PC electrolyte, charge cell at 4 V and discharge to open circuit voltage.

3\*--Use THF electrolyte and discharge to 0.5 V at open circuit.

4\*--Calculated based on active material on the positive electrode.

Table 4. Capacity of Li/PC + 1 M LiClO<sub>4</sub>/PPCC Cell (500°C) vs. Storage Time

Storage time		8 hours	15 hours	24 hours	1 month
Capacity					
Percentage of loss	P <sup>1*</sup>	48.8	63.9	>81.5	—
	N <sup>2*</sup>	—	—	—	<1.0

1\*--P-type cell capacity change.

2\*--N-type cell capacity change.

Table 5. Performance of Li/PC + 1 M LiClO<sub>4</sub>/PPCC Cell vs. Temperature

Temp- erature (°C)	Cell parameters	Open-circuit voltage (V)	Specific capacity (Ah/kg)	Specific energy (Wh/kg)	Coulombic efficiency (%)
100	P <sup>1*</sup>	3.9	86.4	253.4	98.6
	N <sup>2*</sup>	2.8	184.5	285.1	97.1
20	P	3.9	42.5	148.8	84.6
	N	3.0	158.4	266.1	98.4
0	P	3.9	8.3	28.8	50.6
	N	3.2	36.2	48.5	61.4

1\*--P-type cell, charged at 4.0 V and then discharged.

2\*--N-type cell, discharge to 0.5 V.

### III. Conclusions

Based on the results, PCC and PPCC have better intrinsic electrical conductivity and doping characteristics than polyacene itself. In addition, battery electrodes made of PCC and PPCC have 7 and 12 times the capacity, respectively, compared to that of polyacene itself. Their tensile strengths are 5 and 7 times and their impact strengths 15 and 6 times higher than those of polyacene, respectively. Furthermore, they have better mechanical properties. Overall, porous polyacene carbon fiber composite has the best characteristics.

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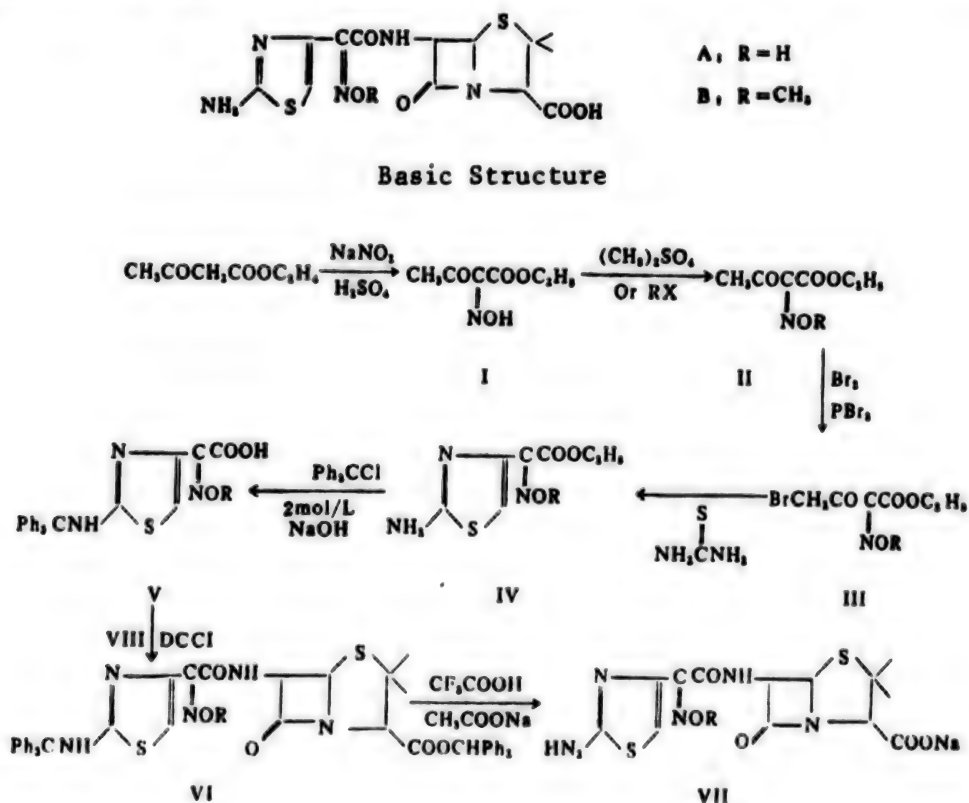


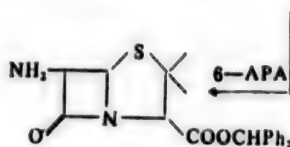
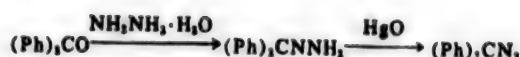
## Studies on Aminothiazo Penicilliate Derivatives

40091024a Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 23 No 9, Sep 88 pp 662-666

[English abstract of article by Shen Zhengwu [3088 1767 2976] and Hui Yunshen [1920 0061 6500] of the Department of Pharmacy, Zhejiang Medical University, Hangzhou]

[Text] Nine aminothiazo penicilliate derivatives were synthesized and their antibacterial activities were tested. The following is the basic structure of the derivatives and their synthetic pathways:





VIII

### Route of Synthesis

### In Vitro Antibacterial Activities of Compound VII<sub>1-8</sub>

Compound	MIC (mg/ml)		
	<u>Escherichia coli</u>	<u>Staphylococcus aureus</u>	<u>Salmonella typhi</u>
VII <sub>1</sub>	15	30	1.698
VII <sub>2</sub>	0.00316	1.58	0.0417
VII <sub>3</sub>	1.62	0.146	0.089
VII <sub>4</sub>	3.75	3.75	0.154
VII <sub>5</sub>	10	2.5	0.095
VII <sub>6</sub>	25	6.75	1.73
VII <sub>7</sub>	10	5.38	6.95
VII <sub>8</sub>	10		
Ampicillin	0.109	0.0758	0.269
Cephalosporin V	0.055	0.076	0.0158

The results from the table show that the anti-Salmonella typhi activity of compound VII<sub>2</sub> is similar to that of ampicillin, weaker in its anti-Staphylococcus aureus activity, and 10 times stronger than ampicillin against E. coli. The results suggest that this analog of compounds deserves further study.

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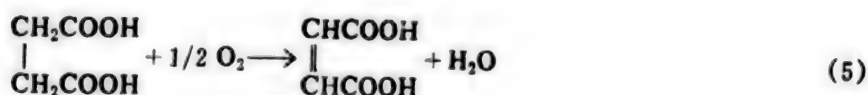
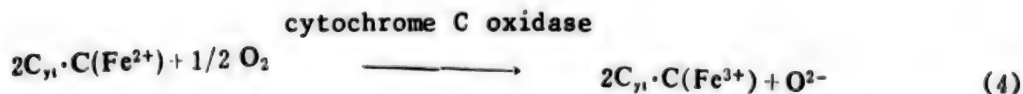
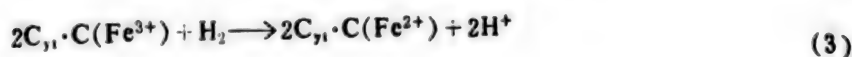
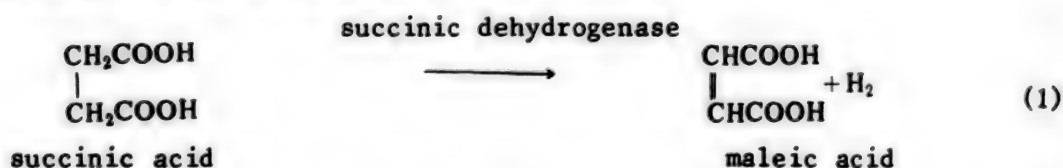
## Studies of Biological Tissue Electrode Sensitive to Cytochrome C (Biosensor)\*

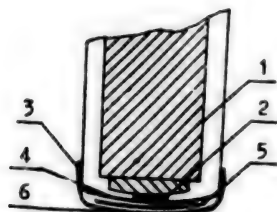
40091024b Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 23 No 10, Oct 88 pp 762-766

[English abstract of article by Shen Guoli [3088 0948 0536], et al., of the Department of Chemistry, Hunan University, Changsha; Xie Jinyun [6200 6930 0061], et al., of the Department of Biology, Hunan Normal University, Changsha]

[Text] A tissue section electrode sensitive to cytochrome C has been made by using a thin slice of porcine kidney coupled with an oxygen electrode. Above the concentration range of 0.01 to 0.227 mg/ml of cytochrome C, the dynamic response of the electrode is linearly related to the logarithm of the concentration of cytochrome C, with a correlation coefficient of -0.9949. Some experimental factors, such as the buffer composition, pH, temperature, tissue slice thickness and preservative agent, have been investigated in detail. The probe is usable for up to 1-2 weeks. The average recovery of cytochrome C assay determined by the dynamic response method is 98.8 percent, with a standard deviation of 3.4 percent.

The principle is as follows:





Schematic Diagram of the Tissue Slice Electrode

1. Ag electrode; 2. Au electrode; 3. Rubber band;  
4. Oxygen-permeable membrane; 5. Porcine kidney  
section; 6. Nylon mesh.

\* Project supported by the National Natural Science Foundation of China.

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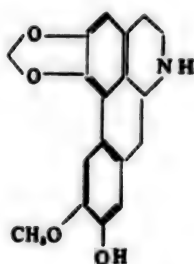
# Studies of Antipyretic, Analgesic Actions of Actinodaphnine

40091024c Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 23 No 10, Oct 88 pp 779-782

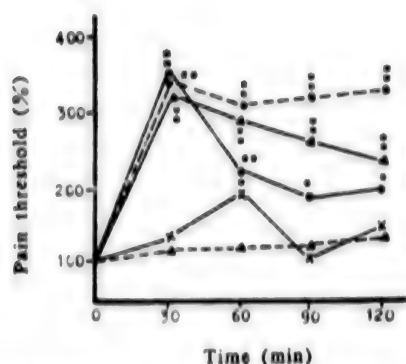
[English abstract of article by Hong Gengxin [3163 1649 6580], et al., of Guangxi Institute of Traditional Medical and Pharmaceutical Sciences, Nanning]

[Text] In this paper, the antipyretic and analgesic actions of actinodaphnine, isolated from *Illigera* SP, are studied. The results are as follows: 1. The normal body temperature in mice, rats and rabbits is reduced by actinodaphnine ip; 2. The fever induced by colibacillus and peptone in rabbits is also markedly reduced by actinodaphnine ip; 3. The writhing response in mice is inhibited and the pain threshold is markedly elevated by actinodaphnine ip. However, the effect of actinodaphnine on the pain threshold in mice (i.c.v.) is not obvious.

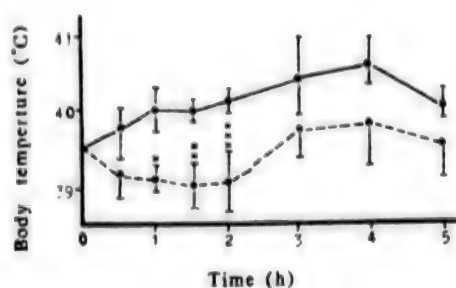
These results indicate that actinodaphnine promotes antipyretic and analgesic actions. The antipyretic action of actinodaphnine is recognized as increasing the loss of heat from the body surface. The analgesic action (hot plate method) of actinodaphnine appears to be not central in nature, but is related to reducing the skin temperature of the mouse palm or to the production of local anesthesia.



Structure of Actinodaphnine



Effect of Actinodaphnine (Ac) ip on the Pain Threshold in Mice (Hot Plate Method). ---- Ac 60 mg/kg;  $\blacktriangle$ — $\blacktriangle$  Ac 40 mg/kg; —•— Morphine 10 mg/kg;  $\times$ — $\times$  Ac 10 mg/kg;  $\triangle$ --- $\triangle$  Saline. \* $p < 0.05$ , \*\* $p < 0.01$  (compared with saline).



Effect of ip Actinodaphnine (Ac) on Fever Induced by Colibacillus in Rabbits (5 animals in each group). ---- Ac 50 mg/kg; —•— NS 2.0 ml/kg; \* $p < 0.05$ ; \*\* $p < 0.01$  (compared with saline).

Effect of Actinodaphnine on the Skin Temperature of Mice Feet

Drugs (mg/kg, ip)	Basic temperature (°C) ( $\bar{X} \pm SD$ )	Temperature difference after drug (°C) ( $\bar{X} \pm SD$ )			
		30	60	90	120 min
Saline	$28.2 \pm 0.4$	$-0.2 \pm 0.4$	$-0.7 \pm 0.6$	$-0.7 \pm 0.4$	$-0.1 \pm 0.4$
Ac(50)	$28.2 \pm 0.3$	$-2.1 \pm 0.3^{**}$	$-1.2 \pm 0.4^{*}$	$-0.2 \pm 0.3$	$-0.4 \pm 0.4$
Ac(20)	$28.2 \pm 0.2$	$-0.7 \pm 0.3^{**}$	$-0.9 \pm 0.3$	$-0.3 \pm 0.4$	$-0.1 \pm 0.3$

\*  $p < 0.05$ , \*\*  $p < 0.01$  (compared with saline)

# Effect of Actinodaphnine on the Skin Temperature of Mouse Belly

Drugs (mg/kg,ip)	Basic temperature(°C) ( $\bar{X} \pm SD$ )	Temperature difference after drug(°C) ( $\bar{X} \pm SD$ )			
		30	60	90	120 min
Saline	36.7 $\pm$ 0.4	-0.1 $\pm$ 0.5	-0.4 $\pm$ 0.4	-0.2 $\pm$ 0.6	-0.2 $\pm$ 0.4
Ac(50)	36.5 $\pm$ 0.3	-3.0 $\pm$ 0.7**	-2.0 $\pm$ 0.7**	-1.3 $\pm$ 0.5**	-1.0 $\pm$ 0.4**
Ac(20)	36.7 $\pm$ 0.3	-0.9 $\pm$ 0.5**	-0.5 $\pm$ 0.2	-0.4 $\pm$ 0.4	-0.3 $\pm$ 0.4
Saline	36.8 $\pm$ 0.4	-0.6 $\pm$ 0.5	-0.7 $\pm$ 0.9	-0.8 $\pm$ 0.7	-0.4 $\pm$ 0.6
Ac(40)	36.9 $\pm$ 0.5	-2.2 $\pm$ 0.7**	-1.5 $\pm$ 0.7*	-1.2 $\pm$ 0.8	-0.9 $\pm$ 0.5

\*  $p < 0.05$ , \*\*  $p < 0.01$  (compared with saline)

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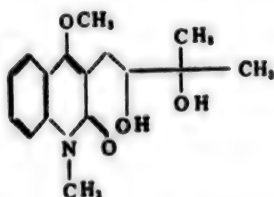


# Edulinine Analgesia, Its Mechanism of Action

40091024d Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 23 No 10, Oct 88 pp 783-785

[English abstract of article by Wei Baowei [7279 1405 0251] and Hong Gengxin [3163 1649 6580] of the Guangxi Institute of Traditional Medical and Pharmaceutical Sciences, Nanning; Chang Zhiqing [1603 1807 7230] and Li Gengsheng [2621 2577 3932] of the Henan Institute of Traditional Chinese Medicine, Zhengzhou; Gu Kunjian [7357 0981 0256] of Shanghai Institute of Material Medica]

[Text] In this report, edulinine analgesia and its mechanism of action are studied. Oral and peritoneal administrations of edulinine have been found to inhibit the writhing response inf mice with ED<sub>50</sub>s of 237.76 and 111.38 mg/kg, respectively. The pain threshold (hot plate) in mice is significantly enhanced by both ip (100 mg/kg) and icv (4 mg/kg) administrations. At a dose of 200 mg/kg (ip), the pain threshold (tail flick) in rats is also significantly enhanced. Pretreatment with either reserpine or pargyline does not influence the analgesia of edulinine. Naloxone (ip) 5 mg/kg is shown to partially antagonize the analgesia of edulinine, but 1 mg/kg does not. It is suggested that the analgesia of edulinine involves partial central action and, although apparently not directly related to the monoamine neurotransmitters, it is probably related to the opiate (kappa) receptors in the brain.



Structure of Edulinine

Chemical name: 4-methoxy-1-methyl-3-(2,3-dihydroxy-3-methylbutyl)-quinolinone-2

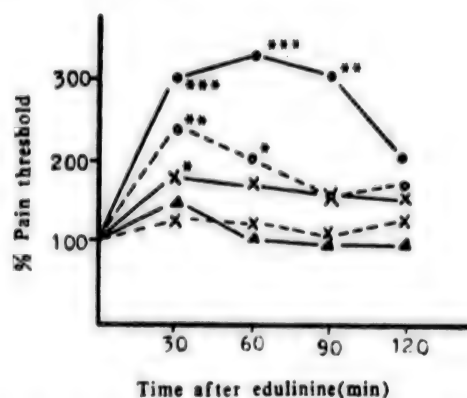
# Influences of Reserpine and Pargyline on Edulinine Analgesia in Mice (Hot Plate Method)

Group	Dose (mg/kg)	Basic threshold	Threshold after drug ( $\bar{X} \pm SD$ ) (s)			
			30	60	90	120 min
P+Ed	75+70	18.6 $\pm$ 4.6	43.1 $\pm$ 15.8***	41.9 $\pm$ 16.1***	37.6 $\pm$ 17.0***	41.7 $\pm$ 18.7***
Ed	70	18.7 $\pm$ 3.9	34.3 $\pm$ 19.0	31.8 $\pm$ 20.1	29.4 $\pm$ 14.8	28.3 $\pm$ 16.3
P	75	18.5 $\pm$ 4.6	20.6 $\pm$ 7.8	21.9 $\pm$ 9.1	18.8 $\pm$ 6.7	20.2 $\pm$ 7.1
R+Ed	1+70	14.4 $\pm$ 3.2	59.6 $\pm$ 1.3***	48.1 $\pm$ 13.1***	37.8 $\pm$ 15.2^	31.7 $\pm$ 17.3^
Ed	70	15.0 $\pm$ 3.6	58.1 $\pm$ 6.0	51.0 $\pm$ 18.2	47.9 $\pm$ 19.3	46.2 $\pm$ 17.3
R	1	15.9 $\pm$ 4.3	18.4 $\pm$ 4.1	20.3 $\pm$ 6.2	22.1 $\pm$ 6.3	20.9 $\pm$ 7.6

P: Pargyline; Ed: Edulinine; R: Reserpine.

\*\*:  $p < 0.01$ ; \*\*\*:  $p < 0.001$  (compared with P or R group)

^:  $p > 0.05$  (compared with Ed group)

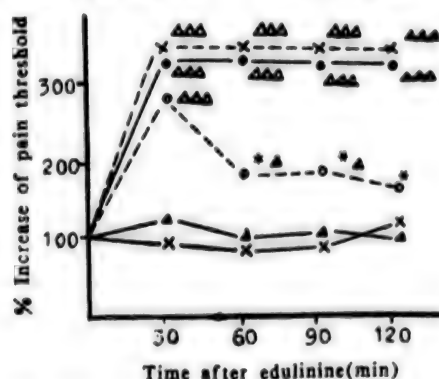


## Effect of Edulinine on the Pain Threshold (Hot Plate) in Mice.

\*\*\*:  $p < 0.001$ ; \*\*:  $p < 0.01$ ; \*:  $p < 0.05$  (compared with the control;

—•—: Edulinine 100 mg/kg ip; ○...○: 4 mg/kg icv (Edulinine);

×—×: Edulinine 70 mg/kg ip; ×...×: Control; Δ—Δ: Edulinine 2 mg/kg icv.



## Effect of Naloxone on Edulinine Analgesia.

—•—: Edulinine 100 mg/kg ip; ×—×: Naloxone 5 mg/kg ip; Δ—Δ: Naloxone 1 mg/kg ip; ○...○: Edulinine 100 mg/kg + Naloxone 5 mg/kg; ×...×: Edulinine 100 mg/kg + Naloxone 1 mg/kg. ΔΔΔ:  $p < 0.001$ ; Δ:  $p < 0.05$  (compared with Naloxone); \*:  $p < 0.05$  (compared with Edulinine).

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## Simple Rapid Method for Duck Hepatitis B Virus Antigen, Antibody Assay

40091022a Shanghai SHANGHAI YIKE DAXUE XUEBAO [ACTA ACADEMIAE MEDICINAE SHANGHAI] in Chinese Vol 15 No 6, Nov 88 pp 413-416

[English abstract of article by Zhang Wei [1728 4850], et al., of the Department of Microbiology, Faculty of Basic Medical Sciences, Shanghai Medical University]

[Text] A dot enzyme immunoassay (dot EIA) for detecting DHBsAg and anti-DHBs is reported. Duck sera for assay of DHBsAg were spotted onto Chinese-made nitrocellulose filters, dried and blocked. The filter membrane was then soaked in rabbit anti-DHBV serum, washed and incubated with peroxidase-labeled staphylococcus protein A, followed by the addition of a 4-chloro-1-naphthol substrate. The DHBsAg positive sera showed purple spots on the filter. When purified DHBV were spotted, this test could be used to assay anti-DHBV. Compared to the DHBV DNA hybridization test of 260 serum samples, the percentage of coincidence between the EIA and the DHBV DNA hybridization tests was 94.2 percent. Rabbit anti-DHBV prepared in the authors' laboratory showed an assay titer of 1:3,200. Dot EIA is not only rapid and simple, but is also specific and sensitive. It will be of practical use in the laboratory for screening large numbers of duck serum samples without requiring sophisticated equipment.

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# Determination of Cytotoxins Produced by Campylobacter Jejuni and Campylobacter Coli by HeLa and Vero Cell Assays

40091022b Shanghai SHANGHAI YIKE DAXUE XUEBAO [ACTA ACADEMIAE MEDICINAE SHANGHAI] in Chinese Vol 15 No 6, Nov 88 pp 441-444

[English abstract of article by Sun Zijie [1327 5261 2212], et al., of Children's Hospital; Song Houyan [1345 0683 3601] of the Department of Biochemistry, Faculty of Basic Medical Sciences, Shanghai Medical University]

[Text] Thirty strains of Campylobacter jejuni and Campylobacter coli were assayed by HeLa and Vero Cells for cytotoxins. Of these 30 strains, 17 were isolated from feces of children with acute diarrhea, 11 from domestic animals and 2 from healthy children. A total of 19 were found to be toxin-producing strains. Among these 19 strains, 13 were isolated from children with acute diarrhea, and 6 from domestic animals. The maximum dilution ( $\bar{x} \pm SD$ ) of ultrafiltrations of C. jejuni and C. coli from children with diarrhea and those from domestic animals which caused 50 percent of the cytopathologic changes in HeLa and Vero cell assays were  $2^{-2.085 \pm 0.6}$ ,  $2^{-2.942 \pm 0.6}$ ,  $2^{-1.274 \pm 0.2}$ ,  $2^{-2.145 \pm 0.7}$ ; and  $2^{-1.941 \pm 0.2}$ ,  $2^{-2.487 \pm 0.6}$ ,  $2^{-1.727 \pm 0.0}$ ,  $2^{-2.691 \pm 0.0}$ , respectively. The titers of the cytotoxins produced by C. jejuni and C. coli in Brucella culture broth after 72 hours were found to be higher than those after 24, 48 or 96 hours.

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# Detection of Pre-S1, Pre-S2 Proteins: New Markers of HBV Replication

40091023a Shanghai ZHONGHUA CHUANRANBING ZAZHI [CHINESE JOURNAL OF INFECTIOUS DISEASES] in Chinese Vol 6 No 4, Nov 88 pp 193-197

[English abstract of article by Yao Guangbi [1202 0342 1732], et al., of the Clinical Immunology Research Unit, Jing'an Central District Hospital, Shanghai]

[Text] The research on HBV Pre-S1 and Pre-S2 proteins among 63 cases of chronic hepatitis B showed that the Pre-S gene products were closely correlated to the replication of the virus. Among 41 Pre-S1 positive cases, 31 were HBeAg positive (75.6 percent), while 32 of the 45 Pre-S1 positive cases were PHSA [polymerized human serum albumin]-R positive. Similarly, among the 32 Pre-S2 positive cases, 27 were HBeAg positive (77.1 percent), while 30 were PHSA-R positive. The present study also revealed that there was a positive correlation between the Pre-S1 and Pre-S2 proteins and HBV DNA and DNA-p. These results suggest that the detection of Pre-S1 and Pre-S2 proteins can be used as the new markers of HBV replication.

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Pathogenic Significance of Enkaphalinin in Epidemic Encephalitis B

40091023b Shanghai ZHONGHUA CHUANRANBING ZAZHI [CHINESE JOURNAL OF INFECTIOUS DISEASES] in Chinese Vol 6 No 4, Nov 88 pp 205-208

[English abstract of article by Zhuge Chuande [6175 5514 0278 1795], et al., of the Department of Infectious Diseases, Ruijin Hospital, Shanghai Second Medical University]

[Text] Leu-enkaphalin levels in the blood and CSF of patients with epidemic encephalitis B during critical and convalescent stages were measured by radioimmunoassay. It was found that the blood leu-enkaphalin levels in 15 patients at the critical stage were significantly higher ( $159.2 \pm 25.45$  pg/ml) than normal levels ( $86.5 \pm 9.2$  pg/ml). The leu-enkaphalin levels in the CSF of eight patients during the critical stage were found to be significantly increased ( $211 \pm 30.23$  pg/ml) ( $P < 0.001$ ). When the patients were convalescing, the leu-enkaphalin levels in both the blood and CSF were increased. The statistical analysis of symptoms suggested that high fever, coma, convulsions and respiratory failure of patients were associated with higher leu-enkaphalin levels in blood and CSF. These results imply that endogenous opioid peptides may be involved in the physiopathologic changes of epidemic encephalitis B.

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**Study of Ultrastructural Abnormality of Circulating Platelets in Patients with Epidemic Hemorrhagic Fever**

40091023c Shanghai ZHONGHUA CHUANRANBING ZAZHI [CHINESE JOURNAL OF INFECTIOUS DISEASES] in Chinese Vol 6 No 4, Nov 88 pp 209-211, 204

[English abstract of article by Guo Ning [6753 1337], et al., of the Institute of Basic Medical Sciences, Academy of Military Medical Sciences]

[Text] The circulating platelets in patients with epidemic hemorrhagic fever (EHF) were studied with transmissive electron microscopy. It was found that the platelets were obviously larger than normal, and the most obvious ultrastructural change was the appearance of the Golgi complexes and rough endoplasmic reticula in the plasma of platelets which were rarely seen normally. These phenomena indicated that the immaturity of the platelets and granular megakaryocytes in bone marrow may have disturbed the EHF maturation. The change in shape was a sensitive feature of the platelet activating response. The ultrastructural abnormalities of the platelets at the early stage of EHF suggested the activation and secretion of the platelets.

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Consecutive Observation of T Cell Subsets of Peripheral Blood in Patients with Epidemic Hemorrhagic Fever by Using Monoclonal Antibody

40091023d Shanghai ZHONGHUA CHUANRANBING ZAZHI [CHINESE JOURNAL OF INFECTIOUS DISEASES] in Chinese Vol 6 No 4, Nov 88 pp 221-224

[English abstract of article by Zhang Xiaoliu [1728 1420 3966], et al., of the Department of Infectious Diseases, Union Hospital, Tongji Medical University, Wuhan]

[Text] OKT monoclonal antibodies were used to detect T cell subsets of peripheral blood in patients with epidemic hemorrhagic fever (EHF). The number of OKT<sub>8</sub> cells began to increase during the febrile phase ( $p < 0.001$ ), and reached its highest level during the shock/oliguric phase. It began to decrease during the diuretic phase, and returned to normal in the convalescent phase. On the other hand, the OKT<sub>4</sub>/OKT<sub>8</sub> ratio decreased during the febrile phase, but reversed during the shock/oliguric phase. The percentage of OKT<sub>4</sub> cells was normal during all phases except the shock/oliguric phase. The decreased and reversed OKT<sub>4</sub>/OKT<sub>8</sub> ratio mainly resulted from the markedly increased number of OKT<sub>8</sub> cells. Since the patients with EHF had humoral hyperimmunity, it is proposed that most of the increased OKT<sub>8</sub> cells were cytotoxic T cells (Tc). The increased number of Tc was probably responsible for the widespread damage to systemic small blood vessels and various organs in patients with EHF.

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Early Diagnosis of Hemorrhagic Fever (EHF) by Using F (ab')<sub>2</sub> Enzyme Conjugates in IgM-ELISA

40091023e Beijing ZHONGHUA YIXUE JIANYAN ZAZHI [CHINESE JOURNAL OF MEDICAL LABORATORY TECHNOLOGY] in Chinese Vol 11 No 6, Nov 88 pp 346-347, 382

[English abstract of article by Qi Tianmao [1477 1131 5399], et al., of the Research Laboratory of Virology, Xi'an Medical University; Xie Weimei [6200 5588 3760] of the Department of Infectious Diseases, First Affiliated Hospital, Xi'an Medical University]

[Text] A new technique for the early diagnosis of EHF, in which the F (ab')<sub>2</sub> enzyme conjugate is used in ELISA to detect the antibodies against the IgM-type EHF virus, has been established in the authors' laboratory. First, high titer positive sera of Rheumatoid Factor (RF) was mixed with the serum containing strongly positive EHF-IgG antibodies (non EHF-IgM), then the sera with strongly positive RF was mixed with EHF-IgM antibodies in different dilutions to simulate the conditions of former and current RF patients with EHF. The F (ab')<sub>2</sub> enzyme conjugate in IgM-ELISA was also employed. The results show that this method can completely eliminate the interference of RF with EHF-IgM antibodies, thereby preventing false-positive results. The results of testing the IgM antibodies of EHF patients show that a 97.1 percent positive rate can be reached in EHF 5 days after onset, and that the highest EHF antibody titer detected is 10<sup>6</sup>.

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Discovery of New Serotype of Salmonella Subgenera III<sub>b</sub> (38:Z61:Z53), Study of Its Biochemical Characteristics

40091023f Beijing ZHONGHUA YIXUE JIANYAN ZAZHI [CHINESE JOURNAL OF MEDICAL LABORATORY TECHNOLOGY] in Chinese Vol 11 No 6, Nov 88 pp 350-352, 382

[English abstract of article by Luo Mingyi [5012 2494 5030], et al., of the Quarantine Station, Shijiazhuang Prefecture; Wu Caifei [0702 6846 5481] and Gu Qingwu [6581 3237 0710] of the National Institute for the Control of Pharmaceutical and Biological Products]

[Text] A new strain of Salmonella subgenera III<sub>b</sub> was isolated from the feces of zoa by the Quarantine Station, Shijiazhuang Prefecture, Hebei Province, in July 1987. Its antigenic formula is 38:Z61:Z53. After thorough observation and identification, it has been confirmed as a new serotype of the genus Salmonella. Its biochemical characteristics accord with the definition of Salmonella except that the organism ferments lactose rather than dulcitol, utilizes malonate and hydrolyzes ONPG. It possesses the typical characteristics of the subgenera III of Salmonella. The pathogenicity of the organism has been proven through animal experiments.

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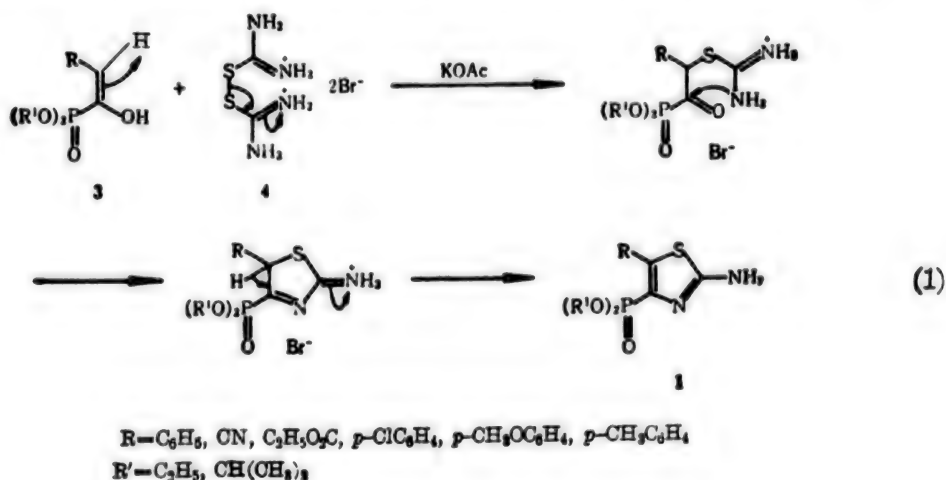
## Synthesis of Dialkyl-2-Amino Substituted Thiazolyl Phosphonates

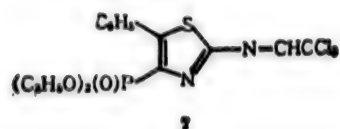
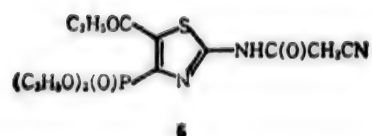
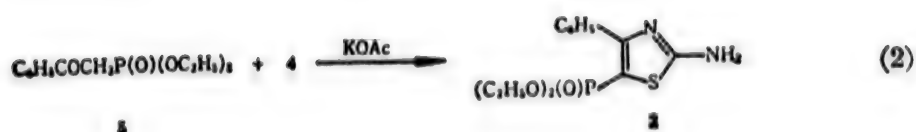
40091026 Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 47 No 1, Jan 89 pp 93-96

[English abstract of article by Hu Bingfang [5170 4426 2455], et al., of the Institute of Agricultural Applied Chemistry, Beijing Agricultural University]

[Text] Many thiazolyl compounds have been found to possess biological activities and have been used as bactericides and weed killers, while research involving synthesizing  $\alpha$ -amino acid analogues and  $\alpha$ -amino phosphate has been continuing. A series of dialkyl 2-amino-5-substituted-4-thiazolyl phosphonates (1) has been synthesized by the reaction of the substituted acetyl phosphonates (3) with formidin-disulfide dihydrobromide (4). Two derivatives of compound 1 have been prepared. However, the reaction between 2-substituted-2-oxo-ethyl phosphonate (5) and compound 4 was carried out under similar conditions, affording the expected product, 2-amino-4-substituted-5-thiazolyl phosphonate (2), only with low yield. The effects of the substituent in the thiazole ring through bonding and non-bonding interactions are indicated by studying  $^1\text{H}$  and  $^{31}\text{P}$  NMR of compounds 1 and 2. A series of substituted acetyl phosphonates (3) has been prepared as synthetic intermediates. The keto-enol tautomerism of compound 3 has been studied by  $^1\text{H}$  and  $^{31}\text{P}$  NMR, and these compounds demonstrated certain degrees of bactericidal activities.

The chemical structures and chemical reactions are as follows:





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Preliminary Study of Epidemic Hemorrhagic Fever (EHF) in Guizhou Province

40091025a Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 1-5

[English abstract of article by Wang Zhaoxiao [3769 2507 1321], et al., of the Sanitary and Anti-epidemic Station of Guizhou Province, Guiyang]

[Text] From 1962 to 1986, EHF cases were reported in 50 of the 82 counties in Guizhou Province, with the northern counties having the highest rates. However, a serological survey of the population showed that the endemic area extended to 51 counties. The inapparent infection rate ranged from 0 to 4.04 percent. In 76 of the 82 counties rodents were found to carry hantavirus. Apodemus agrarius of Zunyi County, Guizhou, and Rattus norvegicus of eastern and southern Guizhou are significant reservoirs of EHF. Hantavirus has been isolated from both patients and rodents.

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# Study of Geographic Epidemiology of Epidemic Hemorrhagic Fever (EHF) in China

40091025b Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 6-10

[English abstract of article by Luo Zhaozhuang [5012 0340 8369], et al., of the Cooperative Survey Group of EHF]

[Text] The EHF distribution, epidemic intensity and focal type in China, on the county level, have been studied through descriptive, serological and geographic epidemiology. The EHF foci were distributed in 1,257 counties in 25 provinces/cities/autonomous regions by 1986, with 633 determined before 1980 and the other 624 determined later. The epidemic area has doubled during the later years. The extension of the rattus-type focus was the most significant. The number of rattus-type foci increased from 20 counties in 1980 (accounting for 3.73 percent of the total foci) to 288 in 1986 (26.77 percent). The mixed type also increased from 98 (18.28 percent) to 267 (24.81 percent), while the apodemus type remained relatively steady.

More than 250,000 small animals were captured and tested during this research. A total of 4 orders, 8 families and 37 species were found to carry the EHF virus antigen. The research pointed out that the main kinds of reservoirs were limited. In addition, the animals carrying the EHF virus were also found in 111 non-case-reporting counties, so these areas constitute potential EHF foci. The relationship between the distribution of EHF foci (especially the apodemus type) and natural geographic factors, such as the physical features of a place, precipitation and water systems, etc., has been analyzed. The preventive strategies and suggestions are also discussed.

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Studies of Inapparent Infection of Epidemic Hemorrhagic Fever in Population of Shanxi Province

40091025c Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 11-13

[English abstract of article by Mi Erying [4717 1422 5391], et al., of the Sanitary and Anti-epidemic Station of Shanxi Province, Taiyuan]

[Text] The detection of the IgG antibody to the epidemic hemorrhagic fever (EHF) virus in sera taken from healthy people in Shanxi Province was carried out by the Indirect Fluorescence Assay Technique (IFAT). A total of 238 out of 4,873 serum samples turned out to be antibody positive, with a total positive rate of 4.88 percent. The inapparent infection rate of EHF in residents of endemic areas was 5.48 percent. A statistically significant difference in epidemic strength was seen among different counties. Based on the analysis of the antibody titers of the positive sera, the value of the upper limit (P95) of the antibody titer for inapparent infection was 1:315. It is suggested that the antibody titer of 1:320 obtained by IFAT in a single serum sample from a patient with clinical manifestations of EHF be used as a criterium for the specific diagnosis of EHF.

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**Preliminary Study of Virulent Difference Between Viral Strains Isolated from *Rattus Norvegicus*, *Apodemus Agrarius* in Fujian Province**

40091025d Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 14-17

[English abstract of article by Li Xianfeng [2621 6343 7685], et al., of the Sanitation and Anti-epidemic Station of Fujian, Fuzhou]

[Text] The virulence level of different viral strains of hemorrhagic fever with renal syndrome (HFRS) isolated from *R. norvegicus* and *A. agrarius* differs, as do their epidemiological features, clinical symptoms and antigenicity. The virulence of the viral strains from *R. norvegicus*, especially of those from nonepidemic areas, is weaker than that of those from *A. agrarius*. Suckling mice are possibilities for use in determining the virulence of the viral strains from various sources. The foci of HFRS has been in southern Fujian, but human cases of HFRS are rarely found, with only a few mild cases found in a few areas. This might be related to the weaker virulence of the viral strains from *R. norvegicus*. The degree of prevalence of the disease might be related to the HFRSV of wild rats in the area.

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Analysis of Distribution of EHF in Different Areas

40091025e Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 18-20

[English abstract of article by Lin Fuxi [2651 4395 4406], et al., of the Sanitary and Anti-epidemic Station of Taizhou Prefecture, Zhejiang Province]

[Text] The data indicates a relationship between EHF and the host animals, as well as the types of natural foci in the plains, hills and mountainous areas of Tiantai County. It is clear that the main host animals are R. norvegicus and A. agrarius in the plain areas, so a mixed focus of R. norvegicus and A. agrarius exists in the above areas. The morbidity of EHF and the positive rate of mouse lung antigen, as well as the inapparent infection rate of the healthy population, are high in the plains. As the altitude rises, the natural focus gradually becomes R. norvegicus as the main host animal in the hilly and mountainous areas. The positive rate of the mouse lung antigen diminishes sharply as the elevation increases, and both the incidence rate of EHF and the inapparent infection rate of the healthy population are lower.

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Study of Hepatitis Delta Virus Infection in China

40091025f Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 21-23

[English abstract of article by Mai Kai [6314 0418], et al., of Henan Institute of Medical Sciences, Henan Medical University, Zhengzhou]

[Text] The antibody to the delta antigen (anti-delta) was detected through ELISA and RIA in 1027 HBsAg-positive persons in 11 provinces, municipalities and autonomous regions in China. No positive anti-delta was found in 634 cases in Beijing, Shanghai, Guangxi, Sichuan, Heilongjiang, Fujian, Liaonin or Henan. Of 393 cases in Inner Mongolia, Xinjiang and Tibet, 17 (4.3 percent) were positive. In these regions, the positive rate of anti-delta in CAH and CPH was much higher than that in chronic HBsAg carriers. It is suggested that HDV infection is characterized by endemic and sporadic features in China and is important in the pathogenesis of chronic hepatitis B.

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# Investigation of Brucella Canis Infection in China

40091025g Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 10 No 1, Feb 89 pp 24-29

[English abstract of article by Shang Deqiu [1424 1795 4428], et al., of the Institute of Epidemiology and Microbiology, Chinese Academy of Preventive Medicine, Beijing]

[Text] A total of 12,949 dogs, 1,676 people and 2,255 animals of 15 species were tested for B. canis infection in 23 provinces and cities of China. The positive rates of dogs in different provinces were different (0.3 - 42.7 percent). The positive rates of dogs in southern China were much higher than those in northern China. The positive rate of females was higher than that of males (2:1), and the positive rate of young dogs (less than 1 year old) was lower than that of older dogs. There was no difference in the positive rates among the other age groups (2 years and older). A total of 166 B. canis strains was isolated from the spleens, lymph nodes and livers of 644 dogs.

Based on the results found when using two dyes, the sensitivity of B. canis isolated from China could be divided into two types: one was resistant to both dyes, while the other was resistant to thionin, but sensitive to basic fuchsin.

Eight serological methods were used in the investigation, with R-SAT and R-RBPT being more sensitive than the others. The positive rate of culturing B. canis was 50 percent when the dogs were selected for isolation at a 1:80 titer. The positive rate of B. canis was 80 percent when the dogs were selected for isolation at a 1:320 titer.

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Fertility Restorer Mutation Induced by  $^{60}\text{Co}$ - $\gamma$  Ray from Wheat Male Sterile Lines in T. timopheevi Cytoplasm

40091025h Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 16 No 1, Feb 89 pp 1-6

[English abstract of article by He Beiru [0149 5563 1172], et al., of the Agronomy Department, Northwestern Agricultural University, Yangling, Shanxi]

[Text] Restorer lines with excellent agronomic characteristics and high restorability were gained by using  $^{60}\text{Co}$ - $\gamma$  ray induction from male-sterile lines in T. timopheevi cytoplasm of T-Xiaoyan No 4A and T-Zhengyin No 1A. The fertility restorer mutation was a kind of dominant mutation involving one or more loci of nucleus genes. Using the male-sterile lines in T. timopheevi cytoplasm with fine characteristics to induce fertility restorer mutation is an effective approach to selecting and breeding restorer lines and exploiting restorer resources.

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Induction of Somatic Cell Callus, Establishment of Somaclone from Triticum Aestivum × Agropyron Intermedium Hybrid

40091025i Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 16 No 1, Feb 89 pp 7-13

[English abstract of article by Wang Guanlin [3769 7070 2651], et al., of the Department of Biology, Northeast Normal University, Changchun]

[Text] Calli were induced from various explants, including leaves, stems, nodes and young inflorescences of the hybrids of wheat × wheatgrass, and somaclones were established. A large number of plantlets were obtained and survived after transplantation.

The induction and differentiation frequencies of the callus were highest with young inflorescence explants, and were lower with stems, nodes and leaves. The callus was not produced from the fully expanded leaves, while it could be induced from the unexpanded young leaves. The location of less differentiation of the young leaves occurred where dedifferentiation took place more readily. The induction frequency of calli from the segments of young leaf bases was at least 90 percent. A modified MS medium supplemented with 4 mg/l 2,4-D, 0.1 mg/l KT, 0.5 mg/l NAA was used for callus formation. The differentiation medium used was the modified MS to which 0.25 mg/l KT, 0.5 mg/l NAA, 150 mg/l Adenylic acid had been added. The induction and differentiation frequencies of the callus from hybrids were higher than those of either parent. The hybrid callus was more vigorous and more adaptive than that obtained from its parents. These may indicate heterosis which is retained in somaclones during tissue culture.

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## Mitochondrial Genome Translation Products, Cytoplasmic Male Sterility in Rice

40091025j Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 16 No 1, Feb 89 pp 14-19

[English abstract of article by Liu Zuochang [0491 4373 2490], et al., of the Institute of Genetics, Chinese Academy of Sciences, Beijing; Zhan Qingcai [6124 1987 2088], et al., of Hunan Academy of Agricultural Science, Changsha]

[Text] According to the analysis of translation products of the rice mitochondria in vitro, it was found through electrophoresis and autoradiograph that the 22 KD polypeptide disappeared in the BT-type male sterile cytoplasm rice (Nonghu 26 A and Fengjin A) as opposed to the fertile cytoplasm (Nonghu 26 B and Fengjin B). These results suggest that the mitochondrial genomes associated with fertility were mutated or rearranged. Although the fertility has been restored in the hybrid ( $F_1$ ) resulting from the cross of the sterile line with the restore line, the 22 KD polypeptide has not yet been found in the translation products of the mitochondrial genome. However, the 22 KD polypeptide band was present in the electrophotogram (stained with Coomassie Blue) of the mitochondrial proteins of the hybrid ( $F_1$ ), and the amount was comparable with that of the fertile line. The polypeptide band was still absent in the gel of the mitochondrial proteins of Nonghu 26 A. It is assumed that the 22 KD polypeptide was encoded by the nuclear genome in the hybrid  $F_1$ , which would complement the failure of the mitochondrial genome related to fertility.

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Morphology, Cytogenetics of Intergeneric Hybrids Between Hordeum Vulgare L.,  
Triticum L.

40091025k Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 16 No 1,  
Feb 89 pp 20-26

[English abstract of article by Jiang Jiming [5592 4949 2494], et al., of the  
Department of Agronomy, Nanjing Agricultural University]

[Text] Intergeneric hybrids of Hordeum vulgare L. ( $2n = 2x = 14$ ) with  
Triticum aestivum L. ( $2n = 6x = 42$ ), T. durum desf. ( $2n = 4x = 28$ ) and  
T. dicoccum Schank ( $2n = 4x = 28$ ) were produced with the aid of an embryo  
culture technique. Cross fertilities of three combinations were 3.0 percent,  
1.2 percent and 0.8 percent, respectively. All hybrids were self-sterile and  
morphologically similar to their wheat parents. Seeds of  $BC_1$  to the male  
parent were obtained on H. vulgare  $\times$  T. aestivum  $F_1$  plants. All hybrids  
showed meiotic instability. The mean meiotic chromosome associations and  
chiasma frequencies of the three hybrids were  $27.3II + 0.33II + 0.01III$ ,  
 $0.45$ ;  $20.57I + 0.20II + 0.008III$ ,  $0.25$  and  $20.41I + 0.28II + 0.005III$ ,  $0.32$ ,  
respectively. This indicates homology between the parental genomes. The  
chromosome counting of the microspores at the first mitotic metaphase in  
barley-tetraploid wheat hybrids showed that more than 60 percent of the  
microspores had 21 chromosomes and were recognized as unreduced male gametes.

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Study of Protoplast Fusion Between Micromonospora Echinospora, Streptomyces Griseus

400910251 Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 16 No 1, Feb 89 pp 49-55

[English abstract of article by Liu Junke [2692 0689 4430], et al., of the Institute of Microbiology, Chinese Academy of Sciences, Beijing]

[Text] Protoplast fusion was performed between the gentamycin producer Micromonospora echinospora 814 (Gm<sup>r</sup>, Km<sup>r</sup>) and streptomycin producer Streptomyces griseus No 45 (Sm<sup>r</sup>, Lm<sup>r</sup>). Fusion bodies were selected by resistant markers with frequencies of from  $10^{-3}$  to  $10^{-4}$ . The detailed fusion process of cytoplasm and nucleoplasm was clearly observed under EM. The resistant markers of the fusion bodies were analyzed. The antibiotic productivities of the fusion bodies were determined, and the yield of one fusion body was increased by 58 percent over that of the parent strain 814. Thin-layer silica gel G sodium carboxymethyl cellulose chromatography showed that the culture broth of some fusion bodies had an unknown spot below gentamycin Cla when compared with parent 814.

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Dependence of *recA* Gene for Replication of Bacterial Chromosome Initiated by Integrated F' Plasmid in Escherichia Coli

40091025m Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 16 No 1, Feb 89 pp 56-66

[English abstract of article by Mao Yumin [3029 5940 3046], et al., of the Institute of Genetics, Fudan University, Shanghai]

[Text] The mutant strain *dnaA46* of Escherichia coli can be integratively suppressed by the F' plasmid. Upon introducing the *recA56* mutation through transduction, the suppressive integration strain (Sin) becomes incapable of growing at 40°C. By means of experiments involving marker transfer, acridine orange sensitivity tests, F' curing and mini-chromosome transformation, it is concluded that the F' plasmid is always in an integrated state in the Sin strains and that the initiation of the replication of the bacterial chromosome is carried out by the integrated F' plasmid. The biosynthesis of DNA and the proteins of the Sin *recA*<sup>+</sup> and Sin *recA*<sup>-</sup> strains at different temperatures have been compared. It is concluded from the experimental results that the *recA* gene functions at the level of DNA replication. The *recA* gene is recognized as the key gene in DNA recombination and SOS repair of DNA damage. The research reported here throws some light on understanding the function of the *recA* gene.

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# Major Issues in Agricultural Science Basic Research

40081028a Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese  
13 Feb 89 p 1

[Article by Lu Liangshu [4151 5328 1859] and An Chengfu [1344 2052 4395]]

[Excerpt] [Passage omitted] II. The Current Situation and Issues in China's Agricultural Science Basic Research

The organizations presently involved in agricultural science basic research in China include the Chinese Academy of Agricultural Sciences and the Chinese Academy of Fisheries, both of the Ministry of Agriculture, and related research academies, institutes, agricultural colleges and universities, integrated universities and some provincial colleges of agricultural sciences. According to statistics of the Ministry of Agriculture, during the period of the "Seventh 5-Year Plan" nationwide, applied basic research tasks only accounted for about 1 percent of basic research tasks in agriculture and the number of people entering scientific research accounted for roughly 2 percent of the total number of S&T personnel. Expenditures for applied basic research in 1987 amounted to slightly over 2 percent of agricultural research expenditures. Since the founding of the country, with respect to material resource aspects such as crop genetical breeding; crops, livestock and fowl, fish resources and also in the fields of plant protection and biotechnology, a number of major accomplishments have been made in agricultural science basic research. According to incomplete statistics, over 40 accomplishments of agricultural basic research have received national-level awards and over 80 have received ministerial awards. A great majority of these accomplishments have been applied, yielding enormous economic returns. An example is the research of Yuan Longping and other agricultural scientists begun in 1964 into the advantageous applications of hybrid rice which led to achievement of the three-line hybridization in 1973, the application of which rapidly spread after 1975. At present, it has been applied on 205.87 million acres, increasing rice yield by 90 billion kilograms for an average increase per acre of 437 kilograms. There will soon be a new breakthrough in the advantageous application of the Indica-Japonica hybrid.

On the other hand, a series of issues have appeared in applied basic agricultural research which cannot be neglected. The major problems include:



--Inadequate emphasis on basic scientific research in agriculture and insufficient knowledge. A trend toward stressing application over theory and emphasizing the present over the long-term has long existed beside the belief that the agricultural sciences are made up entirely of simple, easily understood technical issues. Under the control of concepts such as these basic research receives no priority, is often crowded out of the picture, or when done, lacks assurance. A climate conducive to basic research has not been created.

--Research funding is seriously insufficient. The operational expenditures of agricultural scientific research organizations on a per person basis are very small, in general, only sufficient to support payment of wages. Expenditures for scientific research are smaller still and operational funding for basic research is also lacking. Funds for basic agricultural research come primarily from the Natural Science Foundation, however, there are limits to the subsidies, which amount to only 3 to 4 million yuan annually. Each project receives less than 30,000 yuan. This affects the depth, breadth and progress of the research.

--The research contingent is not stable. Since the reform of the S&T systems the basic research team has been somewhat weakened. Due to inability to obtain funding some S&T personnel have no choice but to abandon basic research and crowd into other projects which are funded. Some apply to the Natural Science Foundation but they themselves can receive no economic benefit, while those engaged in applied research and developmental work can obtain relatively high incomes. This kind of economic inequality brought about by non-complimentary policies has seriously dampened the initiative of basic research personnel.

--Overall planning and deployment are lacking. Due to long-standing departmental divisions, segregation, an absence of comprehensive planning and deployment, dispersal of research capacity, duplication of research, and components that do not compliment each other it is difficult to make major accomplishments of a breakthrough nature.

### III. Strengthen the Planning of Basic Research in Agricultural Science

#### 1. The Objectives and Missions of Basic Research in Agricultural Science

Based on China's national circumstances and current trends in the development of agricultural science and technology, the mid- to long-term objectives and tasks of basic research in agricultural science are: By the end of this century and the beginning of the next to strive to close the gap, on an overall level, between us and the advanced international standard; move some disciplines in which advantages exist into the forefront internationally; manage effectively the 20 to 30 international-level, key agricultural science basic research laboratories and institutes nationwide; establish a 2,000-3,000 strong basic research contingent composed of higher quality young and able personnel, centered closely on the development of a rural commodity economy and the challenge posed by the revolution in new technology.

## 2. Key Research

--Agrobiological resources. Continue to carry out inspection of biological resources in key areas and bodies of water. The collection and protection of agrobiological resources should be accomplished through diverse methods. Systematic research into the development of species peculiar to China should be initiated. An appraisal should be done of all types of biological resources and particularly valuable resources should be genetically analyzed to allow for full exploitation. Genetic stability research for long-term protection of biological resources should be begun. The collection, sorting, classification and evaluation of biological resources of wild origin must be well handled to uncover new types of materials.

--Agrobiological genetic pattern research. Emphasize researching basic improvement of some agrobiological hereditary material with important characteristics to facilitate investigation of new breeding technologies, improve breeding efficiency and foster especially high quality varieties. Research should be begun into the genetic basis of heterosis and the patterns of its expression, quantitative genetics and patterns in population genetics, gene mutation and mechanisms of gene recombination.

--Agrobiological growth, development and control research. Emphasize research into the mechanisms and control of plant photosynthesis, nitrogenfixing by plants, plant nutrition, animal immunology, material transport within the bodies of living organisms and biotic resistance, its mechanisms and control. Also, research should be done into the root system physiology of plants and inter-root movement to provide a theoretical foundation for formation of technological methods of increasing production.

--Study of the mechanisms of agrobiological plant diseases and animal pests. Emphasis should be placed on researching the patterns by which diseases and pests encroach upon crops and livestock, patterns of disease and pest population changes and hidden ecological factors, agrobiological mechanisms of resistance to disease and pests, biological and pharmaceutical prevention mechanisms, and the pathology of livestock sicknesses and parasitic diseases on a molecular level.

--Study of the agricultural environment. Stress should be placed on studying control of the agricultural environment, patterns in the incidence of climatic disasters and their effect on agriculture, the role of forests and grasslands in alleviating water loss, soil loss and climatic disasters, measurement and control of soil fertility and the rational exploitation of water resources.

## 3. Overall Distribution

Those key laboratories and research institutes engaged in agricultural science basic research should primarily be set up in scientific research organizations belonging to the Ministry of Agriculture, in colleges, universities and in related research institutes of the Chinese Academy of Sciences. Some provincial-level agricultural scientific research organizations also must undertake some research tasks.

A rational structure for the research team must be set up which brings into play the guiding function of the older specialists, strives to cultivate middle-aged and younger leaders, attracts a group of young people with doctorates and masters degrees and settles talented scholars returning from study abroad. Planned selection of visiting scholars for travel overseas to carry out joint research should continue along with the invitation of foreign specialists and scholars to China to lecture and engage in cooperative research.

#### IV. Suggestions for Major Policies and Methods

1. Strengthen investment and ensure funding for basic research. Agricultural science basic research should primarily be funded by the state. The management of key laboratories and research institutes should be given key guarantees by the state, and special-fund guarantees should be extended to some projects of a basic nature. The State Natural Science Foundation should increase its subsidization of basic agricultural science projects from the present 3 to 4 million yuan to 10 to 20 million yuan. The Ministry of Agriculture should utilize all channels in the raising of funds and establish an agricultural science development fund to subsidize basic research.
2. Formulate policies to stabilize the basic research team. With respect to those S&T personnel engaged in basic research advantageous policies concerning wages, incentives, benefits, training and appointment to technical duties must exist to allow them to be contented in their work and to eliminate mental and economic pressures. The "Hundred Flowers" policy must be implemented and an academic atmosphere conducive to free inquiry promoted.
3. Formulate regulations and strengthen overall planning. Based on the formulation of the country's middle and long-term technological development priorities, relevant ministries must draw up comprehensive plans for agricultural science basic research to define short, middle and long-term development targets and key research tasks, propose steps and measures, strengthen macroscopic control, concentrate superior capability, put limited research funds to good use and avoid dispersal and duplication.
4. Accelerate the establishment of national key laboratories and centers for experimentation and improve conditions for scientific research. In addition to accelerating the establishment of veterinary biotechnology laboratories, plant disease and pest biological laboratories, centers for the application of Dankelong antibody experimentation to agriculture and animal husbandry and centers for the isolation and examination for disease of crops introduced from abroad; before the year 2000, the state should set up 15 to 20 key agricultural laboratories and centers for experimentation to transform the existing relative backwardness of experimental conditions.
5. Strengthen cooperation and exchange domestically and abroad to establish a new system of open research. Those organizations engaged in agricultural science basic research must open themselves both domestically and overseas. They must publicly recruit institute directors, laboratory heads and project leaders. Conditions must be created for, and support given to participation by research personnel in domestic and foreign academic conferences and cooperative research with foreigners. The holding of international academic conferences in China should be emphasized and supported. This could both expand China's influence and introduce knowledge and technology.

## Developing Biological Fermentation Industry

40081028b Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese  
16 Feb 89 p 3

[Article by Rong Zhimei [2051 1807 2734]]

[Excerpts] Bioengineering technology will yield enormous economic and social benefits when utilized in modern industry even to the point of influencing China's future industrial structure. Striving to develop China's biological fermentation industry is a very urgent task. At present, a great many problems exist in China's development of a biological fermentation industry.

1. Resource limitations. [passage omitted] According to estimates, by the end of this century, the corn supply will only meet 62 percent of demand and supplies of grain other than wheat and rice will only meet 30 percent of demand. This is to say that there will be no alleviation of the shortage of grain for industrial use by the end of this century. The state currently lacks unified planning and management of resources. For example, due to increasing corn prices, established fructose and glucose factories are unable to earn a profit, therefore, they can only operate part-time and the state is forced to spend 330 to 360 million U.S. dollars to import sugar to alleviate the sugar shortage. However, some areas have exported large quantities of corn at low prices to earn foreign exchange.

2. The effect of prices. In the fermentation industry, raw material costs account for a very large proportion of production cost. For example, alcohol accounts for 80 percent and lysine for 50 percent. Existing food price deregulation has caused the production cost for each category of fermentation product which uses agricultural by-products as raw materials to rise. Also, because industrial product pricing is under planned control, a great many enterprises have gone from small profits to losses, even to the point of shutting down.

In the general solvent industry, increasing grain prices have made the cost of producing butanol and acetone by the fermentation method greater than the cost of the synthetic method. The market for general solvents has been severely impacted by the petrochemical industry. The technique of producing ethylene from alcohol produced by fermentation is encountering restrictions arising from inability to compete in terms of cost with petroleum derived



ethylene. The price of molasses, used as a raw material in the production of lysine, has shot upward, raising the price of lysine making it difficult for it to compete with soya bean cake, fish meal, other feeds and imported lysine.

According to predictions of relevant departments the upward trend in prices for the raw materials of fermentation cannot be halted any time soon. Only through opening up new sources of raw materials such as cassava, cellulose and wild plant starch and improving comprehensive utilization can this problem be solved.

3. Backward technology and incompetent management. In China's present fermentation industry there is one kind of bacteria commonly in use, fermentation techniques are many and diverse, production facilities are outmoded, the level of product separation and purification is low, product quality is poor and the level of technological management urgently awaits improvement.

Furthermore, in the development of production which uses agricultural by-products as raw materials, serious pollution and excessive energy consumption still exist. Generally, for every ton of fermentation product, 5 tons of aqueous fermentation waste material will be produced. At present, these waste materials are, for the most part, discarded and good comprehensive utilization and control is nonexistent. It cannot be denied that the pollution generated by the use of biotechnology is much less than that created by chemical methods of production. However, in the wake of the establishment of a large number of rural enterprises, a great many businesses only concern themselves with immediate profit not with environmental problems. This requires the state to provide control through policy.

Based on current conditions in China's fermentation industry and existing problems, in the future attention must be paid to several issues:

1) The use of modern biotechnology to reform traditional biotechnology industries bears on the issue of the prosperity and survival of traditional biotechnology. The development of biotechnology involves agriculture, forestry, animal husbandry, fisheries, light industry and food, the pharmaceuticals industry, the chemical engineering industry and scientific research, production and management. [passage omitted] Currently, China's segregated management system sometimes creates dispersal in the use of funds, poor cooperation, much duplication at low levels and serious waste, all of which are detrimental to the reform of traditional biotechnology industries.

2) Strengthen management and incessantly improve the quality of personnel. If biotechnology is to be high-tech, it is not enough that technological competence be high, advanced production management is also required, the quality of each category of personnel must be good and improved product quality must be a constantly sought after goal. Through scientific management businesses must reduce material and energy consumption and comprehensively utilize by-products in a rational manner to reduce environmental pollution.

Presently most of the fermentation industry is composed of rural enterprises, the production facilities are simple and crude, production techniques are backward, there is much low-level duplication and the technical competence of operating personnel involved in production is limited. On the whole, these personnel have not received any technical training. Capable specialists are in extremely short supply. The majority of businesses rely upon colleges, universities and scientific research organizations for control of technology and unnecessary losses are frequently suffered in production. Therefore, the cultivation of quality by enterprises cannot wait any longer.

3) New types of products must be developed based upon forecasts of domestic and foreign markets and the local resources, environment and conditions to avoid duplication of construction. In recent years, the application of biotechnology has resulted in the very rapid development of a great many fermentation products. Due to urgent demand for products such as citric acid and lactic acid on international markets, a large number of domestic local enterprises have, one after another, begun to compete in production. Both the scale and the number of those involved are becoming larger and larger. Some local production is solely for the purpose of fully exploiting the resources of the area to develop a chemical engineering industry based on agricultural by-products, while some localities lack both resources and guarantees of raw materials. They seek out from everywhere the materials to construct a factory, begin production and earn foreign exchange. Although for a time this will yield relatively good economic returns, as the competition between the enterprises intensifies, those lacking resource advantages certainly will be threatened. Therefore, in determining the types of products to be produced, it is absolutely necessary to be guided by local conditions. One cannot blindly decide to produce those products which yield profits for others. Duplication of construction at low levels is intolerable.

4) Economy of scale in enterprises must be emphasized and each locality must develop according to their own characteristics. The scale of production has a direct effect on the profits of an enterprise. In general, for most fermentation industry production a somewhat larger scale is desirable. For the majority of foreign countries one or two fairly large-scale organic acid factories is sufficient. We consider an annual production capacity of 1,000 to 5,000 tons of organic acid to be an appropriate scale. Each locality's circumstances are different, therefore, when developing the biological fermentation industry, individual characteristics must be developed based on raw materials and technology. We cannot act according to blind imitation.

Agro-Science Research Makes Headway

40101016 Beijing XINHUA DOMESTIC SERVICE in Chinese 1301 GMT 9 Mar 89

[Article by Reporter Chen Jinwu; local broadcast news service]

[Text] Beijing, 9 Mar (XINHUA)--Major progress has been made in tackling the key agricultural scientific and technological projects in the Seventh 5-Year Plan. It is estimated that all the 29 projects can be completed by 1990.

The key agricultural scientific and technological projects in the Seventh 5-Year Plan mainly included research on resources of fine strains of farm crops, techniques for cultivating selected varieties, prevention and treatment of diseases and pests, techniques for making overall improvement in the medium-yield and low-yield regions of the Huanghuaihai Plain, and development of livestock, poultry, and aquatic products.

In research on resources of fine strains of farm crops, a data bank containing 400,000 copies of materials on long-term resources of fine strains has been set up, and a number of new superior, high-yield, disease-resistant, and fast-ripening strains have been cultivated.

New techniques for preventing and treating major farm crop diseases and insects have yielded remarkable effects. According to statistics compiled by 44 experimental demonstration districts, they have kept the losses caused by plant diseases and pests within the planned limits, and saved 20 to 50 percent of insecticide. In 1988, they maintained a total of 1.5 million mu of experimental demonstration fields.

In making comprehensive efforts to improve medium-yield and low-yield regions of the Huanghuaihai Plain, 59 scientific and technological achievements have been made, yielding an economic benefit of 1.5 billion yuan and laying a firm scientific and technological foundation for improving medium-yield and low-yield land and developing the agricultural economy.



### Overall Situation Described for Computer Industry Planning

40080121 Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 1,  
4 Jan 89 pp 36, 38

[Article by Ping Fu [1627 4395]: "The Situation Prevailing During Execution of the Seventh 5-Year Plan for the Computer Industry and Preliminary Concepts for the Eighth 5-Year Plan"]

[Text] At the recent All-China Conference on Computer Efforts and Conference on Software Work, Deputy Director of the Office of Computing of the Ministry of Machine-Building and Electronics Industry, Yang Tianxing [2799 1131 5887], reported on the situation for executing the Seventh 5-Year Plan for China's computer industry and on preliminary thinking on the Eighth 5-Year Plan.

Conditions for implementation of the Seventh 5-Year Plan are excellent.

He said that the plan for gross output value of the computer industry during the period of the Seventh 5-Year Plan, as seen from the situation regarding its execution during the first 2 years, has progressed well. According to statistics from 139 units, in 1986 gross output value rose 5.7 percent over that of 1985. According to statistics from 146 units, gross output value in 1987 rose 48 percent over that for 1986, and it is estimated that growth from 1987 to 1988 will be 18.7 percent.

Output volumes for primary products in 1987 were in fact as follows: 229 mid-to large-size computers, 47,505 microcomputers, 20,559 single-board computers, 32,226 learning computers (including the Zhonghua Learning Machine), 3.5 million calculators, and 164,741 items of peripheral equipment. There were 20,000 sets of software and applications products. Because the state gives high regard to the development of high-technology products, after the state began to implement the policies of liberalization, there appeared in the coastal regions and in the interior a group of enterprises that through various systems and differing operations mechanisms engaged in the development, production, marketing, and service of computers. After several years of growth, some of these enterprises have reached a significant scale, and because some of the enterprises have yet to embrace industrial regulations, planning, and statistical channels, whether it be output value or commodity

quantities, the figures given above are less than they should be, and we plan to supplement these in future statistics. In addition, from the point of view of the share of domestically produced computers in the domestic market, that for the Sixth 5-Year Plan was higher and was tending to grow. It was 73 percent in 1981 and 75.6 percent in 1983. It should be pointed out that markets were closed at that time, so that although the domestic share was higher, the cost-performance ratio and the demands of the customers differed greatly from the situation regarding international products.

After liberalization, foreign machines came into the Chinese marketplace in greater numbers, and the share for domestic machines suddenly dropped, hitting its lowest point (24.4 percent) in 1985. Implementation of the key S&T projects during the Sixth 5-Year Plan and the Seventh 5-Year Plan has enabled us to take great strides in keeping up with developments in international computer technology and with product upgrading, which has greatly reduced the gap between Chinese computer technology and the level of international computer technology. We have made an especially fine record with microcomputers and minicomputers, as well as with their peripherals. The 0520 microcomputer series has rapidly become the mainstream computer within China, and the Taiji 2220 and 2230 superminicomputers and the 8060 mid-sized mainframe have also come onto the market. In addition, small-batch production has allowed the market share for domestic computers to steadily increase, reaching 56 percent by 1987.

Regarding scientific research and development, Deputy Director Yang said that there were two items for the computing industry among major S&T projects on a national scale in the Seventh 5-Year Plan: computer systems research and development and computer software and development, for which 172 contracts were signed. Sixty-two special topics were included in "the more significant among the major projects" of the state. One hundred special topics were included in the hierarchies that centered on "goals for project check-out," which clarified the goals of examination.

In November we surveyed 172 special topics, the great majority of which were progressing well, which is a comforting situation; 2.5 percent of the special projects had already been completed, 21.5 percent of the projects had been evaluated or had achievements from particular stages, 64.6 percent were operating normally, and 11.4 percent were progressing slowly or had not begun. After sorting through our material, we found that over the three levels of administration, contracts had not been significantly altered, which shows that the primary directions for the S&T key projects of the Seventh 5-Year Plan were accurate, that the targeted commodities were correctly selected, and that the technological prospects are on track.

After completion of the S&T key projects planning for the Seventh 5-Year Plan, we will come into a situation wherein China has the technology to manufacture its own 16-bit microcomputers and six important peripherals for that equipment, and will be able to mass produce this equipment, which will

replace imports; we will have developed 32-bit supermicrocomputers and five accompanying peripherals, and will be batch producing the 0600 series of 32-bit general-purpose microcomputer engineering workstations, which will also replace imports. Our share of the domestic microcomputer market will reach two-thirds. In the field of software, we will formulate a group of software standards and norms for China, and will complete 25 commercialized software products and applications systems that meet mid-1980s standards, and that include expert systems for use in artificial intelligence, English (or Japanese)-to-Chinese machine translation systems, image processing systems, and voice recognition and synthesis systems.

During the Seventh 5-Year Plan, we have arranged for a total of 10 projects and 82 special topics in basic research and in preliminary applied research and advance development, the primary research content for which includes: parallel-processing, fault-tolerant minicomputers; supermicrocomputers; software; data bases; image and graphics processing; network technology; new types of peripherals; interactive and intelligent interface technologies; intelligent computer core languages and software engineering; inference engines and relational data bases; intelligent robots; and intelligent expert systems technologies.

Development planning for military computers includes 67 projects during the Seventh 5-Year Plan, chief among which are 9 projects having to do with military ruggedized microcomputer systems and military semi-ruggedized superminicomputer systems.

The focus during the first 3 years was on the development of ruggedized microcomputers, superminicomputers, and their ruggedized peripherals, and during the last 2 years the focus was on developing military high-performance superminicomputers and minisupercomputers.

We can see from our survey of the situation that the majority of projects have progressed well. By the end of 1988, 14 projects, such as the M0572 semi-ruggedized minicomputer system, a military portable microcomputer system, the 0520A vehicle-borne ruggedized microcomputer, and ruggedized peripherals, had advanced to stages of design finalization and technical evaluations. A semi-ruggedized superminicomputer will undergo technical evaluation in the first half of 1989. A military high-performance superminicomputer and a military minisupercomputer have passed program certification, and development has actively begun.

Among the major national new-technology development plans managed by the former State Economic Commission from 1985 through 1987, the most important projects planned were in developmental research in such fields as computer-laser editing-compositor systems, office automation, and computer applications. This segment of the planning has progressed most satisfactorily, and the computer-laser photocomposition system has passed national-level evaluations, which judged that it meets advanced international standards of the 1980s. It is being batch-produced and has gone on sale, not only replacing imports, but it can also be exported for generation of foreign exchange.

Nearly 100 projects were planned for the first two years of the Seventh 5-Year Plan with discount loans for computer applications, primarily consisting of the dissemination of some applications products and applications systems to support the application of computer technology to the extensive field of transformation of traditional industry and to energy conservation, the majority of which projects are now being applied, returning good economic and social results. Tens of thousands of computer applications achievements have permeated all sectors of the national economy to varying degrees, they are serving the transformation to new technology by traditional industries, and they are playing a role in such things as improving quality, lowering costs, conserving energy, improving work efficiency, optimizing product and engineering designs, and hastening the upgrade and renewal of products, as well as advancing the modernization of enterprise management.

Problems still exist while carrying out the Seventh 5-Year Plan.

He pointed out that the primary problems still existing in the execution of Seventh 5-Year Plan are:

1. Gross output value for the computer industry in 1988 grew at a rather slow rate. Annual rates of growth over the last 3 years were greater than 30 percent, but the estimated growth rate for 1988 is only 18.7 percent, in addition to which, for unforeseeable factors, it will be very difficult to accomplish [all goals of] the Seventh 5-Year Plan.
2. In the area of research and development, special projects among the S&T key projects have been insufficiently concentrated; the leading units for some special projects have not taken their leading and organizational roles, and timely coordination has been insufficient; some have been caught up in lateral tasking, which has even led to slow progress in some of these special projects.
3. State efforts at disseminating computer applications have been considerable, but the majority of applications funding is for the end user's equipment. But for several years now, there have been no necessary funding obstacles in the area of research and development for the computer industrial sector and relevant computer applications sectors for relevant computer applications technology, applications products, and applications systems, but actual funding has been seriously deficient. This is a major reason why each department has gone its own way, and has led to low standards with repetitious development.
4. In the areas of technological transformation and capital construction problems have been somewhat greater, which has been primarily manifested in the following: the many projects that have continued in annual planning from the Sixth 5-Year Plan, as few projects have been newly begun; preparatory work by enterprises has not been fully done, which has delayed getting

started, and many opportunities have been missed; the RMB that makes up the funding has not kept pace with foreign exchange, so the foreign currency is not workable, which has led to deficiencies in funding, extensions of the project periods, and has affected the scales of development. For these reasons, during the Seventh 5-Year Plan, there are few technology-transformation and capital-construction projects, and actual starts have been even fewer, which has caused industrial development to be greatly affected.

5. As far as carrying out preferential policies is concerned, the short-term behavior of some enterprises has been serious, consideration of fast profits has been uppermost, and they have not set aside research and development funds from their income from sales, or the proportions they have reserved have been quite low.

The search to make full use of and enjoy funds exempted from taxation by preferential policies has caused these enterprises to short themselves in the areas of benign cycles [between economic activities] and long-term development.

6. An overall loss of control and confusion characterize the import of computers and their fields of circulation. The primary manifestations have been: imported microcomputer products in their original packaging have flooded the domestic markets; some units are altering and reselling whole lots; some lots have been broken up into components and have been intermingled with imports; some have been paid for outside China; some are resold as imported products; some are counterfeits of original equipment; and there are also criminals who are smuggling. This illegal behavior has seriously harmed China's domestic markets, and has affected the healthy development of the computer industry. We are in the process of helping relevant departments to adopt such measures as will clean up and rectify this situation.

The primary efforts that we must now make.

In light of the situation just described, Deputy Director Yang believes that we must pay close attention to the following tasks:

1. We must actively develop new markets both within China and outside it. We must expand the quantities of products for which there are marketing opportunities, and as we expand the Chinese domestic market, we must strive to export and earn more foreign exchange. And we must constantly improve the cost-performance ratio of our products to strengthen their competitive capacities.

2. We must work hard at reforms, must promote scientific research, must adopt effective measures, must marshal our forces, must pay special attention to key S&T projects, and must reduce development time, all of which will allow the more than 200 R&D contracts to produce results earlier and to produce more. This will also allow research achievements to be transformed into commodities and products as quickly as possible.



3. As far as technological transformation and capital construction are concerned, during the next 2 years we must, on the one hand, enhance management and control to enable the projects already in annual planning to be completed with quality and quantity assurances, and on the other hand, we must take control of preparatory work for projects in technology transformation and capital construction, must make great efforts to set projects up early, quicken their initialization, and hasten their results, and must prepare the groundwork for the rapid development of the industry. He recommends that local areas in the provinces and municipalities provide the necessary foreign-currency support for technology transformation projects that are already part of planning.

4. We should correctly carry out the four product preference policies. Funds that are obtained by exemption from taxation through preferential policies should be used for research and development, for developing production, for supporting exports, and for invigorating the economy. They cannot be used for wages and benefits, or for bonuses and housing. In carrying out dynamic management of units enjoying preferential policies, each enterprise so treated shall periodically report on the conditions for the financial implementation of those preferential policies and also on the results so obtained. Each year there should be a survey and readjustment to eliminate units that have not complied and to add units that are deserving.

5. As for research in the computer industry, production units will take the lead in using computers, and whether in breadth of computer applications or in their depth, they will make great advances in hastening their own transformation to new technologies.

6. As far as exclusive capital for production development is concerned, internal bidding or reserve project systems should be implemented for projects that are more mature; we should further clarify major funding directions, using all the funds for the remaining two years to focus on several key projects and to produce a group of results. Development funds should be well managed and used, and they cannot be shifted to other purposes, and we must improve the results of funding by putting less in and getting more out.

7. We must undertake dynamic management of computer production sites to maintain planned fixed sites, yet also be flexible. After a period of operation, planned fixed sites should be adjusted, should retain and attract those enterprise and public-agency units that import, digest, absorb, and innovate, and that also bring results. We must eliminate funding for some fixed-site units that have not produced. Only by incorporating competitive mechanisms can there be vitality in the computer industry.

8. For enterprise and public-agency units that were never included in computer industry planning, as well as those enterprise and public-agency units in the special economic zone windows and that are Sino-foreign financed, if they wish to become part of national industrial planning, we should quickly find the ways to do so, to include them in the industry management.

## Preliminary concepts for the Eighth 5-Year Plan

When discussing the subject of preliminary concepts for planning during the Eighth 5-Year Plan, Deputy Director Yang said that on the basis of our Sixth and Seventh 5-Year Plans, the computer industry in China will develop and build in the Eighth 5-Year Plan, and will take a qualitative leap, which should result in a major turn for the better. There will be the change from third-generation-computer to fourth-generation-computer technology; we will change from a small production economy to economies of scale; and we will change from an internally oriented economy toward an export-oriented economy. Therefore, as far as computer manufacturing in China is concerned, the 5 years of the Eighth 5-Year Plan will be of decisive significance in whether we can constitute a vital industry. It will be an important 5 years, and will also be a 5-year period during which we must foster a bold spirit of all-out effort.

### The guiding ideology behind the Eighth 5-Year Plan.

The guiding ideology for the Eighth 5-Year Plan should be: a continued implementation of the principle of "acting on behalf of utilization," orientation to the two markets, a focus of attention on keeping up with S&T advances and commodity exports, reliance on industrial groups, and the formation of scales of economy.

1. We must continue to implement the principle of "acting on behalf of utilization" by treating the urgent need for equipment and technological transformation in such major sectors of the national economy as energy resources, transportation, metallurgy, petroleum engineering, textiles, machine-building, agriculture, and education as the fields of battle for serving and developing the computer industry.
2. We must vigorously promote the facilitation of S&T advances and the "Taiji" project planning so that we might establish a computer and information industry that is of significant scale and that is centered on mini- and microcomputers. Microcomputers, minicomputers, software, peripherals, and application products that integrate machines with electronics will be the primary products by which to support the industry. At the same time, we must pay close attention to the growth of mid-sized computers and minisupercomputers. Through the implementation of importation and cooperative projects that are related to the development of mid-sized computers, we can further perfect and enhance the technology of the computer industry and the basis of production techniques.
3. By relying upon industrial groups, we can facilitate and build the major engineering projects that can stimulate the entire industry. We can simultaneously support a group of key enterprises. With industrial groups and key enterprises at the core, we can build and form industrial conglomerates that have multiple forms of ownership and complex structures. Between each key enterprise there will be both a mutual division of labor and appropriate overlapping, and that will constitute a competitive status.



4. In the face of major national applications systems, we will put great effort into developing various applications software and applications technology to improve the efficiency of and results from computer applications. In such areas as the systems and support software for micro- and minicomputers, we will steadily progress toward software systems that can be copyrighted on their own. We can make use of the fact of customers' mid-sized and mainframe computer environments to develop sets of support software, applications software, and information systems that accord with our national situation. We will adopt special policies that will enable software exports to experience breakthrough advances.

5. We will make great efforts to develop "the three kinds of enterprises that are either partially or wholly foreign-owned" (wholly foreign-owned, Sino-foreign joint ventures, and Sino-foreign contractual manufacturing), at the same time as we will change the tendency to depend solely upon state funding for growth. We will gather funds from both society and the local areas to encourage a base-level supply of funds.

6. As for the allocation of major projects or products, we will adopt dynamic fixed points, introduce competitive mechanisms, replace the inferior with the superior, and constantly renew, all of which will stimulate growth.

#### Goals for development during the Eighth 5-Year Plan

Deputy Director Yang described the goals for Eighth 5-Year Plan development as: to build up the technology for China's fourth-generation computers by implementing the Eighth 5-Year Plan targets; preliminary formation of applications products as major products that are led by demand, are motivated by S&T advances, are guided by exports, are centered on software, and that integrate mini- and microcomputers with electromechanics; to have a distinct technological power, definite economies of scale, and a significant evolutionary capacity; and to form a computer and information industry that can compete in international markets (including service industries for hardware, software, peripherals, applications, and information).

1. We will enhance research and development for system software, applications software, and public-support technology, will expand the number of people in our software industry to 50-70,000 people, and will build two or three software development and production bases, and 5-10 key software enterprises. By the end of the Eighth 5-Year Plan, we will have preliminarily formed our software industry.

2. With an eye toward applications and the marketplace, we will actively develop and produce various computer applications products, applications systems, and products that blend machinery and electronics, and that serve the many industries in the national economy and the transformation of

traditional industry--products such as CAD/CAM products, and such electromechanical products as office-automation equipment, light printing products, specialized products and tools for the electronification of finance, industrial-control computers, intelligent instruments and meters, medical electronic equipment, and microcomputer-control products. At the same time, we will put great efforts into a computer information service industry, will further improve our computer service system, will set up a nationwide computer marketing network, repair network and applications dissemination networks, and will build a group of overseas marketing, training, and maintenance network nodes to support the manufacturing industry and the sustained growth of applications.

3. Led by exports, we will build 10-20 key enterprise conglomerates that focus on exports, and tentatively, form three export bases.

4. We will absorb and assimilate advanced technology from abroad and will focus on developing fourth-generation computer technology; and to create an excellent supportive environment, we will lay the groundwork for new technology, new techniques, and new structures for developing and producing the fourth-generation of micro- and minicomputers. We will organize forces both within and outside China to join in attacking problems, and will research and develop 100 major projects that will bring the technological level of products at the end of the Eighth 5-Year Plan to that of developed nations at the end of the 1980s, some of those products reaching levels of the early 1990s. Deputy Director Yang believes that during the Eighth 5-Year Plan we should pay more attention to the "Taiji" project planning that will be the basis for fourth-generation computer technology, to the realization of three export-guidance bases, and to two breakthroughs (one being the design and production technology for ASIC [application-specific integrated circuits] circuits, and the other the establishment and preliminary formation of a software industry), which he calls the "4-3-2" plan for short.

U.S. Minisupercomputer Promoted in China

40080150a Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 8,  
1 Mar 89 p 2

[Summary] For the first time, the U.S. firm Sequent Company is putting its super-level minisupercomputer [chaoji xiao juxingji] on the Chinese market. This parallel-processing computer has a tightly coupled multiprocessor design, variable from two to 30 central processing units. Internal memory runs from 8MB to 240MB, and maximum operating speed is 120MIPS [million instructions per second]. The Sequent computer uses the UNIX parallel operating system known as DYNIX.

## Japan To Import Chinese Software

40080150b Bijing DIANZI SHICHANG [ELECTRONICS MARKET] in Chinese 2 Mar 89 p 1

[Summary] Japan's NEC Corp. recently announced that it will import Chinese computer software this year, the first importing of such products from China by Japan. More and more Japanese companies are now engaging in joint development of software projects with Chinese firms in order to help alleviate the shortage of software programmers in Japan, and a Sino-Japanese software center has already received a commission to develop three types of software needed by Japan. An official from the Industrial Structure Council, an advisory board to Japan's Ministry of International Trade & Industry, revealed that Japan's current software market, which has reached the 4 trillion yen level, will rise an additional 3.4 trillion yen by the year 2000, creating a serious shortage of software personnel in Japan.

### Taiwan Evaluates Galaxy Supercomputer

40080150c Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 9,  
8 Mar 89 p 13

[Summary] Taiwan recently delivered an evaluation of the development of the mainland's Galaxy supercomputer, covering the government's decision at the end of 1977 to proceed with development and Deng Xiaoping's personal role in the planning; the 1978 national S&T conference, which set a target date of 1985 for completion of the project; the May 1978 assignment of the project to the National Defense University of Science and Technology at Changsha in Hunan Province; and the formal announcement in December 1983 that the supercomputer was operational. The mainland-produced Galaxy supercomputer, which is similar to and physically resembles the U.S.'s Cray-1, is suitable for complex calculations and data processing in areas such as satellite photographic image processing, petroleum and mineral prospecting, mid-range and long-range weather forecasting, aircraft design, aerodynamic simulation, plasma simulation, power-grid analysis, etc. In the course of the Galaxy's development, designers were faced with two basic problems: the mainland's lack of high-quality spare parts for electronic components, and the backward level of production technology. The several million soldered connections in the main unit were made by young technicians with hand solder guns.

### Naval Research Institute Achievements

40080150d Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 10,  
15 Mar 89 p 2

[Summary] Several achievements of a certain automation research institute in the Naval Research Center were recently exhibited. Included in the 43 command-automation products developed by the institute over the past 6 years are a "network terminal automatic start-stop device," a "touch screen," and applications software packages such as the "Sea Warfare 1" naval tactical command decision-making expert system, the "naval battle computer warfare simulation instructional system," "naval campaign tactical computation software," an "experimental radar-information and command-information rapid transmission system," a "naval warfare operational management system," a "naval warfare graphics display terminal system," "military-unit daily transaction processing software," a "business and chemical-engineering plant management system," and others. These systems have proven effective in raising operating and command-management efficiency several fold.

Fault-Diagnosis System for Second Artillery

40080150e Beijing KE JI RIBAO [SCIENCE & TECHNOLOGY DAILY] in Chinese  
20 Mar 89 p 2

[Summary] The Second Artillery Corps' Engineering Institute recently developed a "machine-machine-dialog intelligent fault-diagnosis expert system," research on which is one of the newest areas in artificial intelligence. Compared to the conventional man-machine-dialog system, this system incorporates advances such as direct automatic measurement of equipment malfunctions, logical inferential analysis, automatic learning functions such as program adjustments and database correction, and so on.



Guided-Missile Storage/Transport System

40080150f Beijing KE JI RIBAO [SCIENCE & TECHNOLOGY DAILY] in Chinese  
20 Mar 89 p 2]

[Summary] The Second Artillery Corps' Engineering Institute has perfected China's first "DYJ-1 guided-missile storage/transport monitoring and control system." This system, which recently passed its technical appraisal, can also be used for checking on valuable precision instruments, civilian mechanical equipment, industrial process-control equipment, and the like.

Storehouses Built for Radioactive Waste

40101017 Beijing XINHUA in English 1035 GMT 13 Mar 89

[Text] Beijing, 13 March (XINHUA)--China is building storehouses for radioactive waste in all the mainland provinces except Hainan and Tibet.

An official from the State Environmental Protection Bureau said that ten storehouses in Anhui, Sichuan, Tianjin and other places will be built this year. Twelve storehouses in other provinces have already been completed.

The storehouses will help to tighten control on the discharge of radioactive waste produced by an estimated 1,000 industries and research establishments across the country.

The official said that some accidental pollution by radioactivity had occurred in recent years because of improper dumping.

The state has spent more than 41 million yuan on building the storehouses, which will have special equipment to monitor radioactivity.

They have been carefully sited to avoid pollution of the environment.

New Numerically Controlled Machine Tools Announced

40080127a Beijing ZHONGGUO DIANZI BAO in Chinese 17 Jan 89 p 3

[Article by Li Huiming [2621 1979 2494]: "Space Machine-Tools Numerical-Control Group Promotes Series of Numerically Controlled Products"]

[Text] The astronautics machine-tools numerical control (NC) group built around Institute No 706 has been guided by the marketplace, and has constantly increased the variety and components for its "Yuntian" brand numerically controlled series of products, and it is making every effort to cover all aspects in order to satisfy the needs of customers. On the basis of the 80-series of products that won for Institute 706 a national silver medal, it has newly developed the series-86 products: four recently announced achievements include two microcomputer numerical control [MNC] systems, the MNC 862 and 866; the SCS-01 numerically controlled servo system; and the model JS23L-A monitor developed by Institute No 23, all of which just recently passed technical evaluations held in Beijing and sponsored by the Ministry of Aeronautics and Astronautics Industry and by the Ministry of Machine-Building and Electronics Industry, where performance was judged to be in the top domestic rank.

The MNC 862 and 866 are both economical semi-closed-loop NC systems. The controller portion of the MNC 862 has as its core a 16-bit microprocessor, and consists of a motherboard with multiple bus structure; the servo driver portion uses the PWM [pulse width modulation] or SCR DC servo driver system to drive the components and a pulse decoder as the detecting element, which then constitutes the semi-closed-loop NC system. The MNC 866 controller portion has the 8-bit 8088 microprocessor as its core, and is arranged around the industry-standard STD microcomputer bus structure. All PC boards plug into the bus motherboard forming a flexible and expandable system.

The NC system just described uses a tactile keyboard, a Chinese-character display, and menu programming method, and it has an interactive function that is suitable for dual-axis semi-closed-loop lathes and other industrial control.

The model SCS-01 NC servo system is an automatic control system with a definite feedback function. It is the central link between the micro-computer NC system and the machine tool, and it is the execution component of the microprocessor numerical control, which is adaptable to various models of motors by setting or adjusting just a few parameters. This can meet the demands of either economical or mid- to high-range numerical control.

The JS23L-A monitor is a matching component of the machine-tool control, and is the "eye" of the NC system operation.

The four achievements just described have been through sample development and small-batch test production, and have been successful in test link-ups with lathes at relevant machine-tool plants. These efforts have proven the completeness of the functions, the stability and reliability of performance, and the ease of operations and maintenance; each technical indicator meets the design requirements.

NC Form-Control System Developed

40080146b Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS]  
in Chinese 18 Feb 89 p 1

[Summary] The DIGIT OZC numerically controlled (NC) form-control [fangxing kongzhi] system developed by Professor Lu Jiechi [4151 2638 2170] and his associates at the Precision Machinery Research Institute of Dalian Science and Engineering University recently passed the technical appraisal sponsored by the State Education Commission. This system, which meets international standards of the early eighties, unites various functions such as NC machining, form [i.e., replication] machining, and digitized [display], and is especially suited to machining of complex[-shaped] precision parts for national defense, aeronautics and space, automobile, shipbuilding, and tool and die industries. China's large outlays of foreign exchange for importing this critical technology in recent years are not appropriate for current conditions, so the commission assigned this project four years ago. In addition to the aforementioned functions, this system, based on 16-bit general-purpose micro-processors, also has CAD/CAM, pantograph [i.e., reduction/amplification], and mirror-image functions. All of the applications software is independently developed and the hardware is all domestically manufactured.

## Dynamic Error Analysis of Radar Antenna Axial Angle Encoder

40080046b Shanghai DIANZI JISHU [ELECTRONIC TECHNOLOGY] in Chinese Vol 15  
No 8, Aug 88 pp 12-14

[Article by Pan Guirong {3382 6311 2837}]

## [Text] I. Working Principles of Axial Angle Encoders

An axial angle encoder is a device which uses angle measuring components and signal processing circuits to convert the axial angle of a machine to digital signals. There are many programs for axial angle encoder implementation, including amplitude encoding, phase encoding, combined amplitude-phase tracking encoding, and others. Given the complexity of circuits and component restrictions, China uses several amplitude encoding programs, and their working principles will be described briefly here.

Assuming that the angle measurement unit is a rotary transformer, a block diagram of rotary transformer-type axial angle encoder principles is shown in Figure 1. The output voltage signal from the rotary transformer used to measure the machine axial angle  $\theta$  is

$$v_1 = V_m \sin \theta \sin \omega_0 t$$

$$v_2 = V_m \cos \theta \sin \omega_0 t$$

The  $\omega$  [lower-case omega] in the formula is the excitation frequency, and the sample values in high-speed applications should take into consideration both system dynamic performance and rotary transformer angle measurement performance. These two amplitude-modulated AC signals are used to derive the DC signals  $V_m \sin \theta$  and  $V_m \cos \theta$  which contain the axial angle  $\theta$  after passing through a demodulation filter. These two DC signals pass through a comparison circuit which determines if  $\sin \theta$  is greater than 0, if  $\cos \theta$  is greater than 0, and if  $|\cos \theta|$  is greater than  $|\sin \theta|$ .

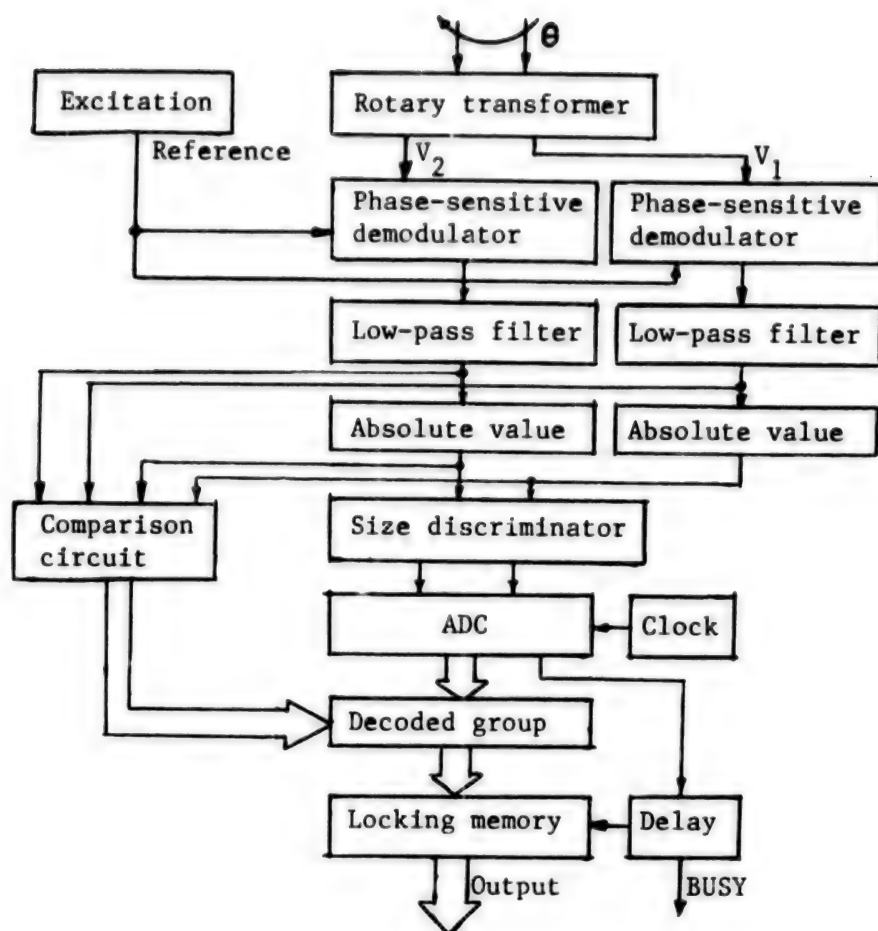


Figure 1: Block Diagram of Axial Angle Encoder Principles

One can see from the waveforms of the sine and cosine signals that the output of these three comparators contains information with  $\theta$  high-three-order symbol bits, and  $\theta$  high-three-order binary data is derived after processing. Then,  $\theta$  is divided into eight  $45^\circ$  octants to assure that there is a single value for the ADC [analog-digital converter] sine and cosine functions. In addition, with high-three-order control, after the two DC signals described previously pass through an absolute-value DC circuit and a size-discrimination circuit, the selected large-signal  $V_m \sin \theta$  (or  $V_m \cos \theta$ ) goes to the ADC reference input end and the small signal  $V_m \sin \theta$  (or  $V_m \cos \theta$ ) goes to the ADC signal input end. The clock CP converts the ADC to  $|\tan \theta|$  or  $|\cot \theta|$  data. After this data passes through a non-linear decoding circuit, it is combined with the high three bits, providing binary digital signals for angle  $\theta$  over a  $360^\circ$  range.



With single-board software processing, this program substantially reduces the work load of the axial angle encoder hardware and increases its flexibility. Moreover, the ratio conversion method in this program has definite anti-interference properties, so this program is more reliable.

## II. Dynamic Lag Error in Axial Angle Encoders

There are two situations in which an axial angle encoder is used at high speeds. One is a rather high rotation speed of a radar antenna axial angle, and the other involves using a multipole rotary transformer to increase angle measurement precision. Assuming that the multipole rotary transformer's number of pole-pairs is  $n$ , the machine axial angle  $\theta$  is increased in speed  $n$  times electrically. In these two situations, normal axial angle encoders can create considerable dynamic lag error.

Assuming  $n = 32$  and an antenna axial angle rotation speed of 10 r/min, two problems will appear in the usual axial angle encoder applications.

The first problem is that computer-processed axial angle encoding has advantages like high flexibility, conservation of equipment and materials, and so on, but its software computing time can cause substantial dynamic lag error. Our experience indicates that when using TP-801 to process one axial angle code, the longest software computing time can be about 700  $\mu$ [lower-case mu]s, so the input dynamic lag error  $\theta_{\text{DECODE}}$  is

$$\begin{aligned}\theta_{\text{DECODE}} &= - \text{rotation speed} \times \text{pole logarithm} \times \text{lag time} \\ &= - 10 \text{ r/min} \times 32 \times 700 \mu\text{s} \\ &= - 1.3^\circ\end{aligned}$$

$\theta_{\text{DECODE}}$  affects the dynamic performance of the axial angle encoder angle measurement and because it is a lag link, it can seriously affect utilization of axial angle encoders in radar angle digital follow-up systems.

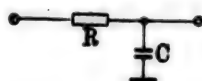


Figure 2. Low-Pass Filter Circuit

The second problem is the low-pass filter in the axial angle encoder's analog channel. The low-pass filter design usually requires that the system have a sufficiently high static precision, so a filter circuit like the one in Figure 2 which is quite inert and provides rather good filtering effects is employed. Its transmission function is

$$H(s) = \frac{1}{1 + \frac{s}{\omega_c}}$$

In the formula,  $\omega_c = 1/RC$  and the filter's phase-frequency characteristics are

$$\varphi \text{ [lower=case phi] FILTER} = -\operatorname{tg}^{-1} \frac{\omega}{\omega_c} = -\operatorname{tg}^{-1} \frac{f}{f_c}$$

After passing through the phase-sensitive demodulator, the output signals from the rotary transformer are

$$V_{\text{DEMODULATOR 1}} = V_m \sin \theta |\sin \omega_0 t|$$

$$V_{\text{DEMODULATOR 2}} = V_m \cos \theta |\sin \omega_0 t|$$

Using a Fourier series expansion, we derive

$$V_{\text{DEMODULATOR 1}} = V_m \sin \theta (A_0 + A_1 \sin 2\omega_0 t + A_2 \sin 4\omega_0 t + \dots)$$

$$V_{\text{DEMODULATOR 2}} = V_m \cos \theta (A_0 + A_1 \sin 2\omega_0 t + A_2 \sin 4\omega_0 t + \dots)$$

When  $\theta$  is a fixed value, meaning there is static debugging, the DC components  $V_m \sin \theta$  and  $V_m \cos \theta$  are extracted after the output signals from the phase-sensitive demodulator pass through a low-pass filter which filters out the high-frequency components  $2\omega_0$ ,  $4\omega_0$ , .... and so on. However, when there is a definite frequency of variation in  $\theta$ , for example, assuming that  $\theta = \omega t$  (in this example,  $\omega = 2\pi \times 5.33$  Hz), while the high-frequency component is filtered out by the low-pass filter, it also creates phase lag of the low-frequency signals  $V_m \sin \theta$  and  $V_m \cos \theta$ . This phase lag is actually the dynamic lag error  $\theta_{\text{FILTER}}$  in the axial angle encoder. For this article, we assumed that  $f_c = 80$  Hz and  $f = 5.33$  Hz, so the angle dynamic lag value at the input of the one-stage low-pass filter in Figure 2 is

$$\theta_{\text{FILTER}} = \varphi_{\text{FILTER}} = -\operatorname{tg}^{-1} \frac{f}{f_c} = -3.8^\circ$$

It is apparent that the dynamic lag error due to phase shift in the one-stage low-pass filter is rather large. A two-stage low-pass filter to improve static properties would lead to even greater input dynamic lag error. When the antenna axial angle  $\theta$  rotates at a constant speed, hardware or software compensate for the dynamic lag error, but when the antenna axial angle rotates at an irregular speed, consideration must be given to this dynamic lag error in the angle measurement system.

Dynamic lag error has these effects on axial angle encoders:

1. It affects the precision of angle measurement by the axial angle encoder. For example, a  $3.8^\circ$  precision-machine angle lag value converts to a coarse-machine value of

$$3.8^\circ / 32 = 7' = 0.002 \text{ rad}$$

2. It affects the accuracy of data output. As is commonly known, a dual-channel angle measurement system has an error-correction capability within a certain range. For example, a 32 bipolar dual-channel axial angle encoder has an error-correction range of  $\pm 2.8^\circ$ . It is very possible that a large dynamic lag value would exceed this error correction range, causing loss of synchronization in the circuit error-correction function and the appearance of errors in the output data.

3. Generally speaking, the computing time for computer-processed angle encoding is constant and the software processing circuit is equivalent to a simple delay link. This can affect system indices and stability in a closed digital follow-up system.

### III. Application and Implementation

The static precision of the dynamic lag error in high-speed applications of the axial angle encoder described above can be made very high by the choice of ADC bit number and the number of pole-pairs of the dual-speed angle measurement components, whereas dynamic error is due mainly to the lack of real-time circuit response. Dynamic performance and static performance are mutually contradictory. In high-speed axial angle encoder applications, we must strive to improve dynamic system indices without hurting static performance.

Figure 1 shows that dynamic error in axial angle encoders is due mainly to the low-pass filter and the delay time of the decoder IC. The phase-sensitive demodulator in the analog processing circuit has a rather broad bandwidth, so it is a small inert link relative to the low-pass filter and can be ignored. In digital processing circuits, the ADC aperture time is related to chip choice. In usual selections, a high-speed-grade bit-by-bit comparator ADC like the ADC0808 has an aperture time of only  $16 \mu\text{s}$ , with the shortest being  $10 \mu\text{s}$ , so it can be ignored relative to the software computing time. Angle  $\theta$  in the axial angle encoder is expressed as the signal phase throughout the program. We mainly used the angle of the phase transmission function to reduce the phase lag value, thus reducing the dynamic lag error.

#### A. Reducing software decoding processing time ( $T_5$ )

Complex hardware non-linear decoding problems exist in hardware axial angle encoders, meaning how can hardware be used to implement arc tangent (arc cotangent) problems. It is very easy to solve decoding problems with a single-board computer, and software processing functions like error compensation, zero-point autochecking, and so on can be added, so it is very flexible to use a single-board computer to process axial angle codes.

A single-board software processing circuit is represented in the system as a delay link with a transmission function of

$$H(s) = e^{-sT_s}$$

Its phase lag is

$$\phi_{\text{TRANSCODE}} = -\omega T_s$$

In the formula,  $\omega$  is the antenna axial angle  $\theta$  variation frequency and is directly proportional to the axial angle rotation speed, while  $T_s$  is the software decoding processing time.

$T_s$  is the only factor in the decoding circuit which affects the dynamic angle error. The arc-tangent decoding circuit should have software flexibility as well as the speed of hardware processing. For this reason, we implemented an arc-tangent (arc cotangent) program which uses hardware to achieve software performance. A block diagram of its working principles is shown in Figure 3.

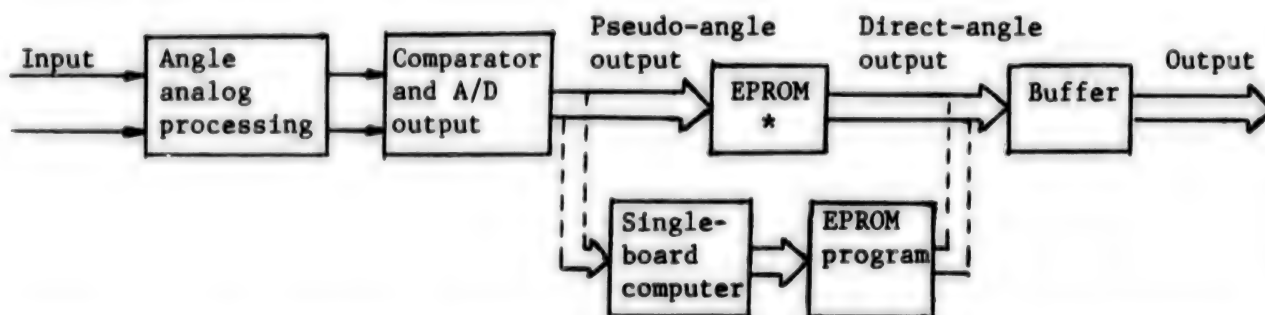


Figure 3: Block Diagram of Hardware Experimental Arc-Tangent and Arc-Cotangent Implementation (\* = erasable programmable read-only memory)

We know that the binary digital signals output by the comparator and analog converter usually have 11 to 14 bits. Using 14 bits as an example, this 14-bit binary digital signal contains 14 bits of information on the angle  $\theta$ . Thus, this 14-bit pseudo-angle digital signal (output by the comparator and analog converter) has a corresponding relationship with the 14-bit true-angle signal. The single-board-computer-processed angle is merely based on the 14-bit pseudo-angle signal which is re-output after processing by a predetermined program. This permits substitution of hardware EPROM (or PROM) for the single-board computer to implement hardware processing of arc-tangent (arc-cotangent) decoding, giving it flexible functions similar to single-board computer processing.

The content of the EPROM in Figure 3 includes seven software functions: 1) Differentiating between arc tangents and arc cotangents; 2) Computing the non-linear decodes from  $\text{tg}\theta$  (or  $\text{ctg}\theta$ ) to  $\theta$ ; 3) Computing the cyclic-binary transformations of the high-three-order symbol bits; 4) Achieving integration of A/D outputs with comparator outputs; 5) Capability of implementing precise and rough data correction and integration with multipolar rotary-changing axial angle encoding; 6) Offering program-based compensation functions for static and dynamic system error; 7) Easy adjustment, checking, and correction of angle baseline zero position. These functions in experimental or system debugging and the selection of a single-board computer for measurement processing can provide an axial angle encoder with optimum performance. Then, EPROM programming can be used to provide EPROM hardware implementation with the same functional flexibility as microcomputer processing.

Adoption of this program reduced the decoding time  $T_d$  from the original 700  $\mu\text{s}$  with software processing to 0.5  $\mu\text{s}$  (the EPROM read time). This greatly improved system dynamic performance, increased the data rate, and eliminated pure delay links in the system, thereby raising stability indices of the digital follow-up system. Because this program does not directly use a single-board computer, the volume of the axial angle encoder is reduced, and single-channel encoding can be done on a 140 X 200 mm PC board, which increases reliability and simplifies operation and maintenance.

#### B. Reducing phase lag in low-pass filters

Phase lag in low-pass filters used in analog processing inevitably causes angle lag error in the system. To solve this problem, suitable phase compensation must be provided to this phase-lag type of low-pass filter. A phase-compensation filter was designed for this purpose.

The design requirements for the phase-compensation filter were to effectively filter out the field AC component and create the smallest possible dynamic lag value for an axial angle  $\theta$  signal at a specific frequency (i.e., the rotation frequency). Its design principles are that, given the rather good filtering characteristics of the high-order low-pass filter along with the large phase-lag value, a suitable zero point must be established in the channel to create the corresponding phase lead value and to compensate as much as possible within the input rotation speed for the phase lag value of the low-pass filter.

Based on these requirements and principles and through repeated debugging experiments, the transmission function  $H_{\text{FILTER}}(S)$  of the phase compensation filter we designed is:

$$H_{\text{FILTER}}(S) = \frac{1.350 \times 10^{15}(1 + 1.427 \times 10^{-3}s)}{s^5 + 1.511 \times 10^4 s^4 + 6.471 \times 10^6 s^3 + 9.609 \times 10^9 s^2 + 1.857 \times 10^{12} s + 1.350 \times 10^{15}}$$



There are two reasons for the rather high step number of this filter. One is dynamic lag compensation caused by an insufficiently wide bandwidth in the phase-sensitive demodulator. The other is that it avoids losses of static precision caused by phase compensation. The phase characteristics of the phase compensation low-pass filter are:

$$\varphi_{\text{FILTER}}(\omega) = \text{tg}^{-1} 1.427 \times 10^{-3} \omega - \text{tg}^{-1} \frac{1.857 \times 10^{12} \omega - 6.471 \times 10^6 \omega^3 + \omega^5}{1.350 \times 10^{15} - 9.609 \times 10^9 \omega^2 + 1.511 \times 10^4 \omega^4}$$

One group of values computed using this formula is shown in Table 1.

Table 1.

Rotational speed (rpm)	0	20	120	300	480	600	720	900
Frequency (Hz)	0	1/3	2	5	8	10	12	15
Phase lag	0	0.3'	1.7'	3.6'	4.4'	3.8'	2.2'	-3'

Rotational speed (rpm)	1080	1200	1320	1500	1680	1800	1920
Frequency (Hz)	18	20	22	25	28	30	32
Phase lag	-11'	-20'	-31'	-53'	-82'	-106'	-135'

Table 1 shows that when the input signal frequency of the phase-compensation filter is 30 Hz (the axial angle rotation speed is less than 2,000 r/min), its phase lag value is very low, so the dynamic lag error in the angle measurement is also very small. Thus, the axial angle encoder can display the true axial angle of the antenna in real time.

#### IV. Experimental Results and Analysis

We made approximate analog measurements of the dynamic performance measurements of the axial angle encoder, and the experimental data obtained should serve only as a reference.

The first dynamic measurement problem is measuring the non-linear decoding time  $T_S$ . Because of the rather widespread use of EPROM and the generally acknowledged read time of only 0.5  $\mu$ s,  $T_S$  is 0.5  $\mu$ s.

The second dynamic measurement problem is measuring the phase lag characteristics of the phase-compensation filter. A block diagram of the experiment with it is shown in Figure 4.

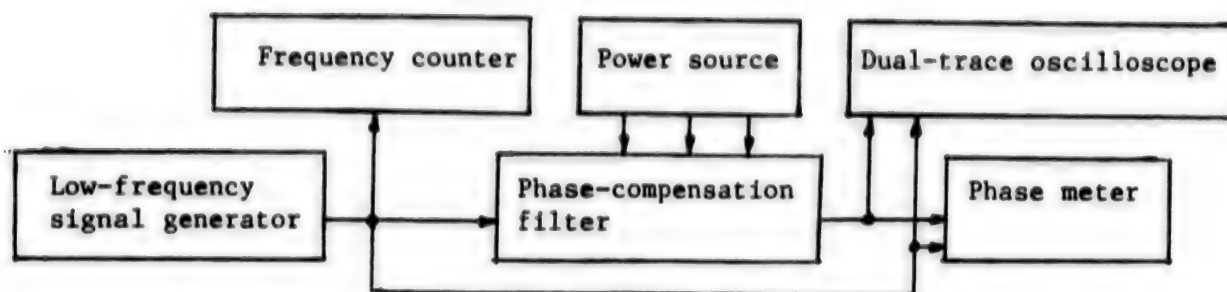


Figure 4: Block Diagram of Filter Phase-Lag Characteristics Experiment

Given restrictions by experimental conditions, we substituted low-frequency signal generators for the antenna rotation-angle analog signals and used them to simulate the low-frequency component  $A_0 V_m \sin \theta$  in the phase-sensitive demodulator output signals. In it  $\theta = 277$  ft, with  $f$  being the output frequency of the low-frequency signal generator. In one path, this low-frequency analog signal passes through the phase compensation filter and is output to the phase meter. On the other path, it serves as a baseline signal for direct output to the phase meter. The error value of the phase error between the signals in these two phase meters is displayed using the decimal system, meaning the phase-lag value of the phase-compensation filter. The measured experimental data are shown in Table 2.

Table 2.

Signal frequency (Hz)	8	10	15	18	20
Phase differ. (measured)	-0.3°	-0.1°	-0.2°	-0.6°	-0.7°
Phase differ. (theoretical)	0.1°	0.1°	-0.1°	-0.2°	-0.3°
Signal frequency (Hz)	22	25	28	30	32
Phase difference (measured)	-0.8°	-1.5°	-1.3°	-1.2°	-1.6°
Phase difference (theoretical)	-0.4°	-0.9°	-1.3°	-2.0°	-2.3°

Since the precision of the phase meter is only  $0.5^\circ$ , the measured data can only be used as a reference. The signal frequency rose from 0 to 32 Hz, equivalent to an increase in rotation speed from 0 r/min to 2,000 r/min. It is apparent from Table 2 that regularities in the measured variation of phase lag in the phase-compensation filter approximated the theoretically computed values, so one can see that the designed filter has definite compensating effects.

This program was adopted to develop a small and highly reliable axial angle encoder which performed excellently in on-line debugging experiments.



## New Modeling Method of Filtering for Tracking Maneuvering Targets

40080052a Beijing DIANZ' KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 10 No 5, Sep 88 pp 400-407

[Article by An Lingling [1344 0407 0407], Gu Huaijin [7357 2037 3866], and Xu Zhenlai [1776 2182 0171] of the Nanjing Electronic Technology Institute, Nanjing; manuscript received 17 Jan 87, revised 7 Sep 87]

[Excerpts] Abstract: This article suggests a new modeling method for maneuvering-target-tracking filtering. It treats target maneuvering acceleration as a state variable for inclusion in the model and direct estimation, and uses Kalman filter residuals to determine if a target is maneuvering. When target maneuvering is detected, the Kalman filter is immediately reactivated to adapt to jumps in maneuvering acceleration. Optimum filtering was achieved in this situation using a new adaptive filtering method. Computer simulation results show that while the method described in this article involves far fewer computations, its filtering precision is equivalent to the filtering precision of the Moose method.

## I. Introduction

A maneuvering target refers to a target which is exhibiting random movement. Its dynamic differential equation can be written as:

$$\dot{x}(t) = -\alpha x(t) + u(t) + n(t).$$

Here,  $\alpha$  is the air damping coefficient,  $n(t)$  is random perturbation due to environmental interference, and  $u(t)$  is the pilot-controlled random acceleration. Usually, known statistics on  $u(t)$  are hard to obtain. It is unknown and undergoes frequent jumps. This makes it hard to use direct Kalman filtering, which requires a known parametric dynamic structure, to implement maneuvering-target-tracking filtering. Thus,  $u(t)$  processing has become the key to solving problems in maneuvering-target-tracking filtering. Much research has been done in the past 20 years on using Kalman filtering theory for maneuvering-target-tracking filtering and many methods have appeared. The more representative among them are methods proposed by Singer,<sup>1</sup> Moose,<sup>2,3</sup> Chan,<sup>4,5</sup> and others.

Singer treats target maneuvering as a stationary correlation process and uses a parametric determination model for filtering. Moose visualizes the  $u(t)$  discretization sequence as a semi-Markov process which assumes  $N$  discrete values. The Kalman filter output for  $N$  known accelerations  $u_i$  is weighted to achieve self-adaptation to target maneuvers. Chan views  $u(t)$  as the known constant  $u$ . He used the method of least squares and second-order Kalman-filter output residuals to estimate this maneuvering quantity  $u$  and then used the estimated value  $\hat{u}$  to correct the Kalman-filter output. In the method employed in this article,  $u(t)$  serves as a state variable entered into a state equation for direct recurrent estimation. This avoids filter system complexity caused by assuming  $N$  discrete values of  $u_i$  in the Moose model and the rather large maneuvering estimation error due to independent estimation of the amount of maneuvering using residuals in the Chan method, thereby achieving optimum state estimation of unknown parameters in the mode. A maneuvering detector is used to detect jumps in  $u(t)$ . When target maneuvering is detected, a third-order Kalman filter is reactivated immediately to carry out a new filtering process, thereby achieving adaptive tracking filtering for maneuvering targets. To assure consistent asymptotic stability, we also derived the range of the filter gain component  $K_3(t)$  steady-state value  $K_3^*$ .

[Passage omitted]

Kalman filtering theory indicates that  $V(t)$  in the above formula [not reproduced] is a zero-mean independent Gaussian process. The formula shows that the appearance of  $\Delta u \delta(t - \tau)$  means that the output residual of the designed filter is no longer simply  $V(t)$  because of the appearance of the linear increase signal  $\tilde{y}^\Delta(t)$  which contains the random parameters  $\Delta u$  and  $\tau$ . It is manifested in actual filtering as an increase in filtering deviation due to maneuvering over time, and eventually can cause filtering divergence. This is because  $K(t)(t \geq \tau)$  is very small when maneuvering occurs, so estimates of the state maneuvering component  $\hat{X}^\Delta(t)$  cannot keep up with changes in the state maneuvering component  $X^\Delta(t)$ . In physical terms, when a "high-frequency" component appears in the input signal, if the filter can simultaneously automatically increase the "frequency bandwidth" (i.e., increase the gain), this can give the filter an excellent "high-frequency" response and maintain tracking filtering. We used the above analysis to design a maneuvering signal detector for the designed filter-output residual. When maneuvering occurs ( $\tilde{y}^\Delta(t)$ ), it immediately reactivates the filter and carries out a new filtering process, achieving adaptive filtering for maneuvering targets.

A block diagram of the adaptive filtering system is shown in Figure 1.

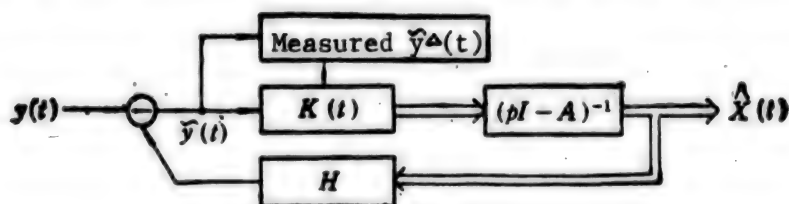


Figure 1. Block Diagram of Adaptive Filtering System

[Passage omitted]

We chose two typical target-movement laws for analog simulation experiments and compared them with the simulation results of the Moose algorithm. The first example involved flight with intermittent abrupt acceleration and the second involved flight with turns. Each example was computed 50 times, the total tracking time was 10 seconds, and the sampling interval was 0.01 second. We computed the estimated root-mean-square error and estimated arithmetic mean for the two algorithms. The curves are plotted in Figures 2 and 3.

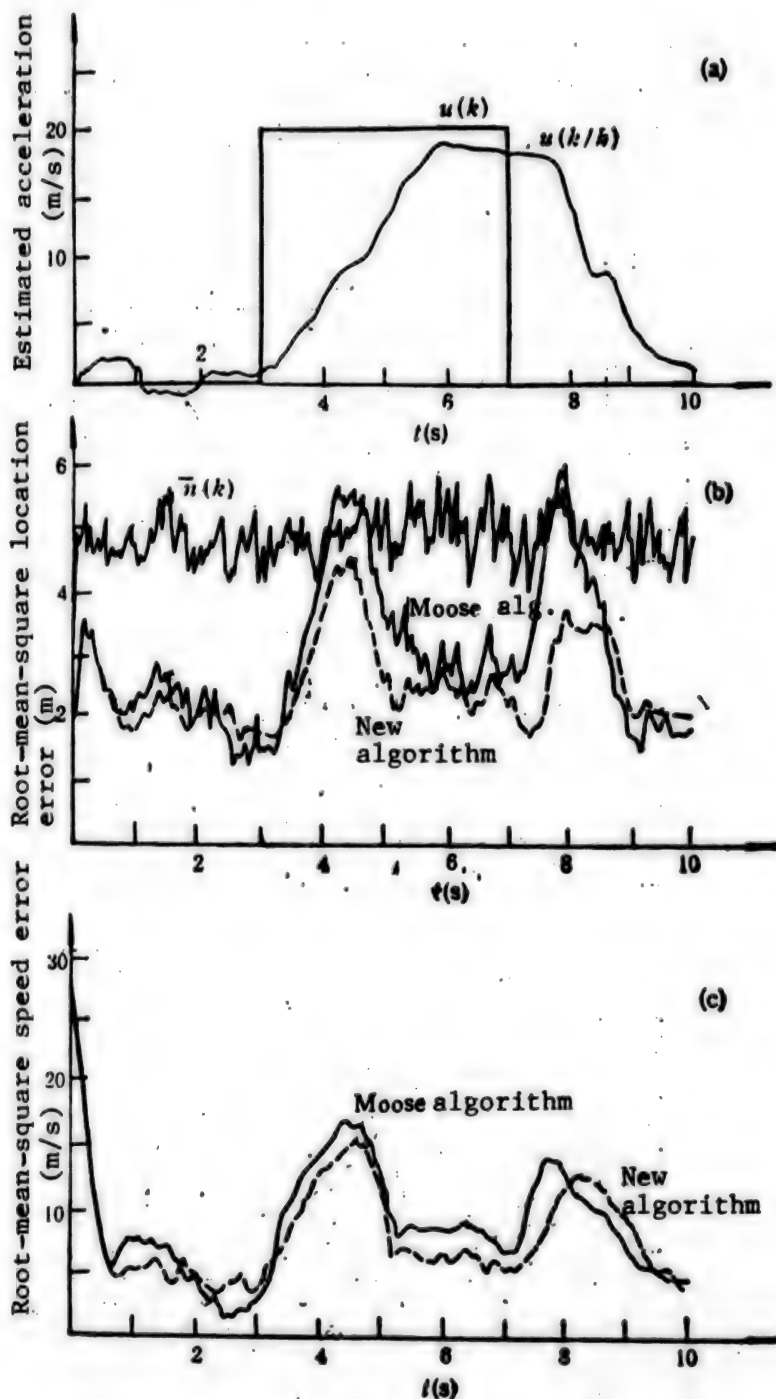


Figure 2. Comparison of Computed Results

----- Root-mean-square error of new algorithm  
 ——— Root-mean-square error of the Moose algorithm

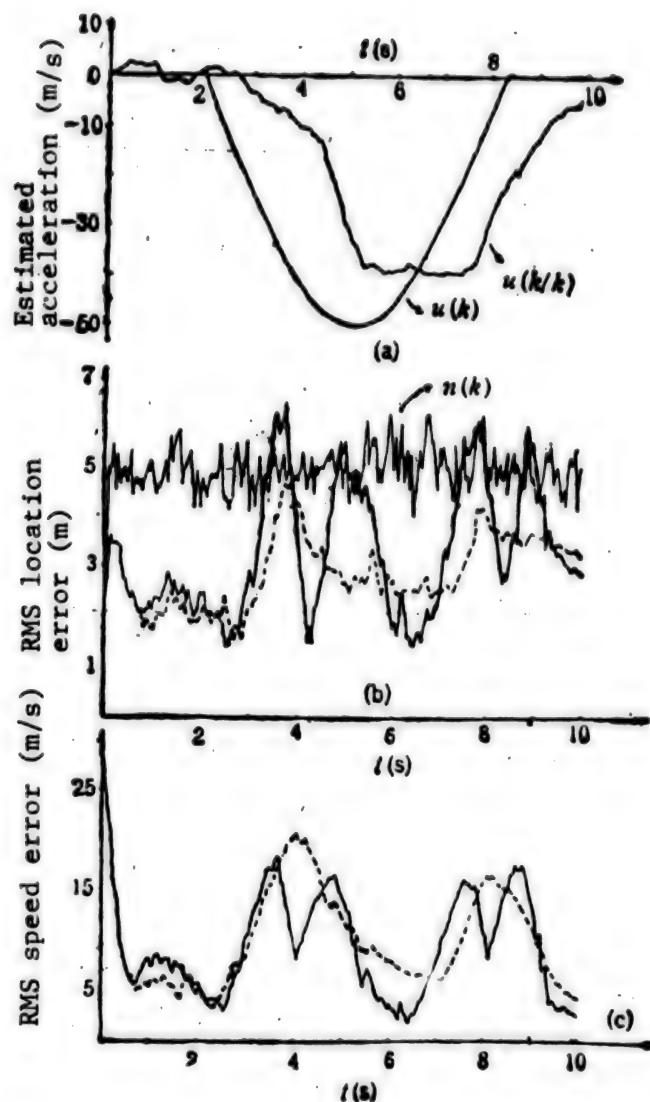


Figure 3. Comparison of Results of Computer Simulation

-----Root-mean-square error of new algorithm  
 ———Root-mean-square error of the Moose algorithm

## VI. Conclusion

The modeling method proposed in this article achieved optimum state estimation of unknown model parameters. Application of this method can achieve rather good tracking filtering of maneuvering targets and it can maintain excellent tracking even in the event of abrupt and significant maneuvering. This method is easy to implement and involves fewer computations than the Moose method. Computer simulation experiments indicate that the estimation precision of this method is equivalent to the estimation precision in the Moose method.

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Self-Interference of Spontaneous Radiation in Free-Electron Lasers

40080052b Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 10 No 5, Sep 88 pp 439-442

[Article by Wang Changbiao [3769 2490 2871] and Liu Shenggang [0491 4141 4854]  
of the Chengdu Institute of Telecommunications Engineering, Chengdu [now  
renamed the University of Electronic Science & Technology]: "Self-  
Interference of Spontaneous-Radiation Pulses in Free-Electron Lasers";  
manuscript received 23 Jun 87, revised 17 Aug 87]

[Excerpts] Abstract: This article uses Green's function to compute spontaneous radiation of a monopulse electron beam in a helical-magnetic-field free-electron laser (FEL). The results show that the electron beam to a limited extent may give rise to self-interference of spontaneous-radiation light pulses.

I. Introduction

There has been extreme interest in basic research on FEL's since the first successful experiment with them.<sup>1</sup> This research led to the discovery of sideband instability<sup>2</sup> and the short-pulse effect.<sup>3</sup> The short-pulse effect refers to intense correction of the spontaneous-radiation spectral line shape which has a substantial effect on light output power when the center wavelength of the spontaneously radiated light within the pulse length of the single electron beam is approximately the same as the magnetic-field cycle count in the interactive region.

This article solves a one-dimensional wave motion equation to calculate the spontaneous radiation of a monopulse electron beam in helical-magnetic-field FEL's. The computed results show that both short-pulse effects and long-pulse effects exist in the spontaneous radiation of FEL's. The long-pulse effect refers to the appearance of multiple peaks in the spontaneous-radiation spectral line when the center wavelength of the spontaneously radiated light within the pulse length of the single electron beam is sufficiently greater than the magnetic-field cycle count within the interactive region.

Analysis indicates that both short-pulse and long-pulse effects in spontaneous radiation are due to interference in the spontaneous-radiation light

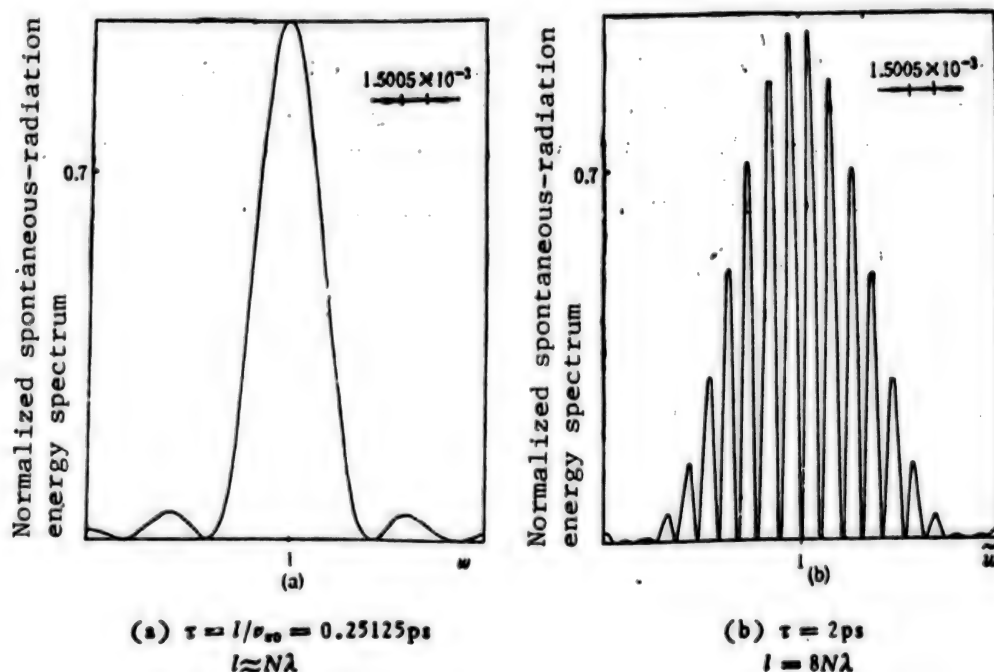


pulses. When the electron-beam pulse length is too short, frequency-spectrum spreading due to the finite length of the interactive region is much smaller than frequency-spectrum spreading due to the finite length of the electron beam and there is no noticeable self-interference at this time. When the electron-beam pulse length approaches  $N\lambda$  ( $N$  is the magnetic cycle number within the interactive region and  $\lambda$  is the center wavelength of the light), there is contention between frequency-spectrum spreading due to the finite length of the interactive region and frequency-spectrum spreading due to the finite length of the electron beam. This contention causes intense correction of the spontaneous-radiation spectral line shape and begins to create self-interference. When the pulse length of the electron beam is much greater than  $N\lambda$ , frequency-spectrum spreading due to the finite length of the interactive region is much greater than frequency-spectrum spreading due to the finite length of the electron beam. At this time, the spontaneous radiation spectral line contains multiple peak values and obvious self-interference appears.

[Passage omitted]

#### IV. Physical Results

$M$  in formula (7) [not reproduced] is a pulse-modulation factor. It is this factor which describes self-interference of spontaneous-radiation light pulses in FEL's. As shown in Figure 2, when the length of the electron beam approaches  $N\lambda$ , self-interference is manifested as a short-pulse effect. When the length of the electron beam is greater than  $8N\lambda$ , self-interference is manifested as a long-pulse effect.



Computed

parameters:  $n = 1, r_s = 131, r_m = 100, L = 1.5 \text{ m}, \lambda_m = 1.5 \text{ cm}, N = 100$

Normalized angular velocity:  $\tilde{\omega} = \omega(1 - \beta_m)/\omega_0$

Figure 2. Energy Spectrum of Spontaneous Radiation

According to Madey's theorem,<sup>4</sup> the gain spectrum of FEL's under small-signal conditions is proportional to the derivative of the effects of spontaneous radiation on initial electron energy. Thus, the long-pulse effect may cause multiple peaks in the gain spectrum, indicating that its gain varies for signals at different frequencies, which in turn causes variation in the frequency-spectrum structure of the pulse and the pulse shape after amplification.

Finally, it should be pointed out that if the electron-beam pulses are too short, experimental observation of self-interference is difficult. The reason is that the oscillation peak infinite density frequency spectrum becomes a continuous spectrum. In addition, poor quality electron beams also can eliminate self-interference.

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# Constantly Polarized Conical-Scanning Antenna Without Nutating Feed

40080052c Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 10 No 5, Sep 88 pp 443-448

[Article by Zhou Wenfu [0719 2429 3940] and Zhang Rirong [4545 2480 2837] of the Shijiazhuang Communications Institute, Shijiazhuang: "A Conical-Scanning Auto-Tracking Receiving Antenna Without a Nutating Feed Source"; manuscript received 9 Jan 87, revised 15 Mar 88]

[Text] Abstract: This article describes a conical-scanning auto-tracking receiving antenna which does not use a nutating feed source. When used to track linearly polarized signal targets, it eliminates structurally complex nutating rotating joints and is both inexpensive and quite stable. Feed source and antenna measurements show excellent homogeneity and polarization characteristics of the beam off-axis angle. When tracking linearly polarized signal targets, the antenna attitude is stable, target acquisition is rapid and accurate, and tracking performance is satisfactory.

## I. Introduction

Unlike an auto-receive auto-transmit radar antenna, a conical-scanning auto-tracking receiving antenna with a feed source composed of an oscillator fitted with a reflector cavity used for tracking linearly polarized signal targets cannot use a rotary oscillator because rotation of the oscillator would cause additional modulation, which is impermissible. Some in foreign countries have used a nutating oscillator feed source.<sup>1</sup> However, China has not yet developed nutating joints and they have extremely complex structures, so we decided to replace the oscillator nutating feed source by opening various numbers of slots and holes at suitable locations on one side of the reflector cavity in order to use leakage of the electromagnetic field from the slots and holes to achieve an off-axis beam lobe. With a reference electric motor (a Tzk-305 three-phase hollow-shaft magnetic hysteresis motor) directly driving rotation of the reflector cavity (frequency 25 Hz), the antenna's off-axis beam lobe rotates at the same frequency around the axis line of the paraboloid to form a conical-scanning beam. The amplitude of the received radar signals does not vary when the target is in the direction of the paraboloid axis line, whereas a 25 Hz angle tracking error signal is created when the target is off-center from the paraboloid axis line. Compared to a nutating feed source, this program has the advantages of being less expensive,

lighter in system weight, high in stability, and so on. Because very little power enters the receiving antenna, signal lines and reference signal lines can be easily rigged up using, respectively, flexible cable and multicore flexible cable. This eliminates added noise from the long rigid casing extending out from the center of the paraboloid during the feed source rotation process.

## II. Working Principles

The feed source substituted for the nutating feed source is shown in Figure 1. When activated by a symmetrical vibrator, the  $TE_{11}$  mode, which is the lowest higher-order mode excited in the coaxial line within the coaxial reflector cavity, has a field component of:<sup>2</sup>

$$E_r = \pm V_1^* \frac{1}{r} z_1 \left( \frac{\mu_1}{b} r \right) \sin \phi$$

$$E_\phi = V_1^* \frac{\mu_1}{b} z_1 \left( \frac{\mu_1}{b} r \right) \cos \phi$$

$$E_z = 0$$

$$H_r = -I_1^* \frac{\mu_1}{b} z_1 \left( \frac{\mu_1}{b} r \right) \cos \phi$$

$$H_\phi = \pm I_1^* \frac{1}{r} z_1 \left( \frac{\mu_1}{b} r \right) \sin \phi$$

$$H_z = -\frac{j}{\gamma} \frac{\lambda}{\lambda_{c,1}} V_1^* \frac{\mu_1}{b} z_1 \left( \frac{\mu_1}{b} r \right) \cos \phi$$

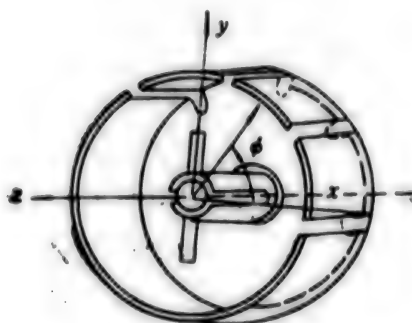


Figure 1. Coaxial Reflector Cavity

Dimensions of the coaxial cavity should be chosen to ensure that the  $TE_{11}$  mode can be transmitted and that the vertical slot in the reflecting cavity walls dissects the current created by the magnetic field  $H_z$  and induces leakage. If the vertical slot extends to the bottom of the cavity to form a hole in the bottom of the cavity, the hole will dissect the  $H_r$  component.

$H_z = H_{z\max}$  and  $H_r = H_{r\max}$  when  $\phi = 0^\circ$ , so leakage from the slot and the hole in the bottom of the cavity is greatest. In contrast,  $H_z = 0$  and  $H_r = 0$  when  $\phi = 90^\circ$ , so leakage from the slot and the hole in the bottom of the cavity is least, as shown in Figure 2.

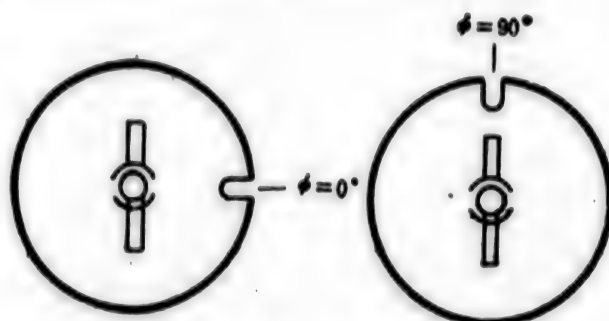


Figure 2. Reflector Cavity With a Single Slot and Hole

Obviously, for the two extreme conditions of  $\phi = 0^\circ$  and  $\phi = 90^\circ$ , the excessive difference in electromagnetic field energy leakage from the slot and hole is reflected in extreme non-homogeneity of the off-axis angle of the wave lobe on the H plane and  $\phi = 90^\circ$  E plane directional plots when the feed source  $\phi = 0^\circ$ . This is unacceptable in tracking. With several slots instead of a single one at suitable locations, the fact that the slots and holes are always located between  $\phi = 0^\circ$  and  $\phi = 90^\circ$  reduces leakage differentials in the directional plots for the  $\phi = 0^\circ$  H plane and the  $\phi = 90^\circ$  E plane in both situations. This greatly improves homogeneity in the off-axis angle for the  $\phi = 0^\circ$  H plane and  $\phi = 90^\circ$  E plane directional plots, as shown in Figure 3. This program achieves excellent conical scanning of off-axis angles.

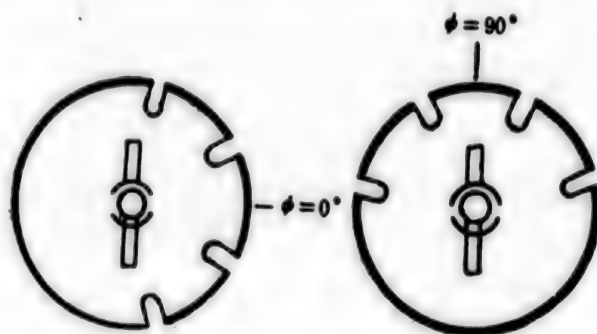


Figure 3. Reflector Cavity With Several Slots and Holes

### III. Experimental Results

If the hole at the bottom of the cavity shown in Figure 2 is filled in, leaving only the slot, the measured H-plane directional plot when the feed source  $\phi = 0^\circ$  is shown in Figure 4. Figures 5(a) and 5(b) show, respectively, the measured feed source directional plots for both the  $\phi = 0^\circ$  and  $90^\circ$  states when the hole at the bottom of the cavity in Figure 2 is opened up.

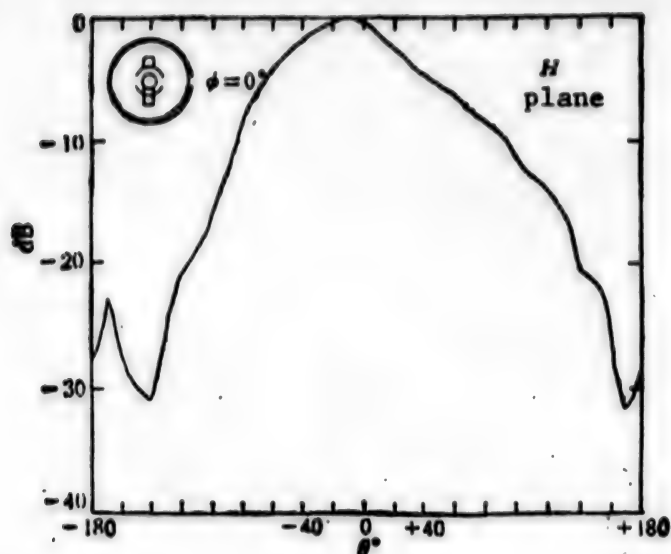


Figure 4. Directional Plot of Feed Source With Single Slot

Figures 4 and 5 show that the wave-lobe off-axis angle difference is smaller when the reflector cavity has one slot than when it has a slot and a hole. They show clearly that leakage from the slot is more significant while leakage from the hole in the bottom of the cavity is rather small, which also plays a secondary role in improving homogeneity of the off-axis angle.

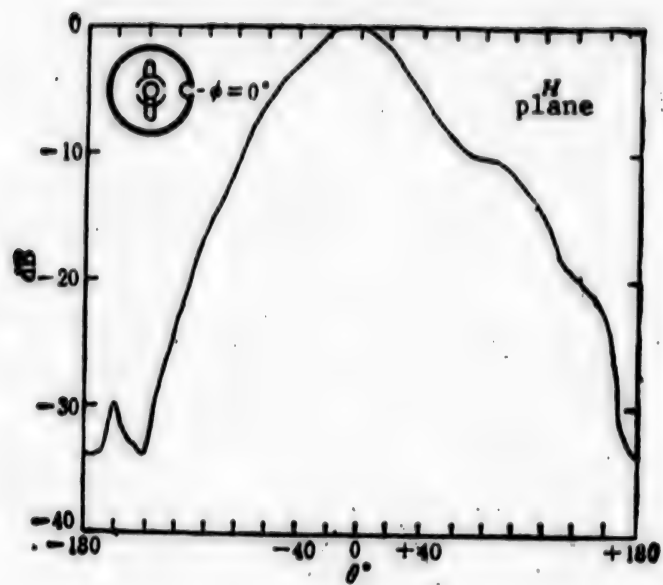
Figure 5 shows that when one slot and one hole are opened in the wall of the reflector cavity, the H-plane wave-lobe off-axis angle is rather large when  $\phi = 0^\circ$  (or  $180^\circ$ ), whereas the E-plane wave-lobe off-axis angle is nearly zero when  $\phi = 90^\circ$  (or  $270^\circ$ ), so the results confirm the above analysis.

Figures 6(a) and 6(b) show, respectively, the measured feed-source directional plots for both situations shown in Figure 3. The off-axis angles of the E plane and H plane are nearly equal, indicating that excellent homogeneity has been achieved in the off-axis angle.

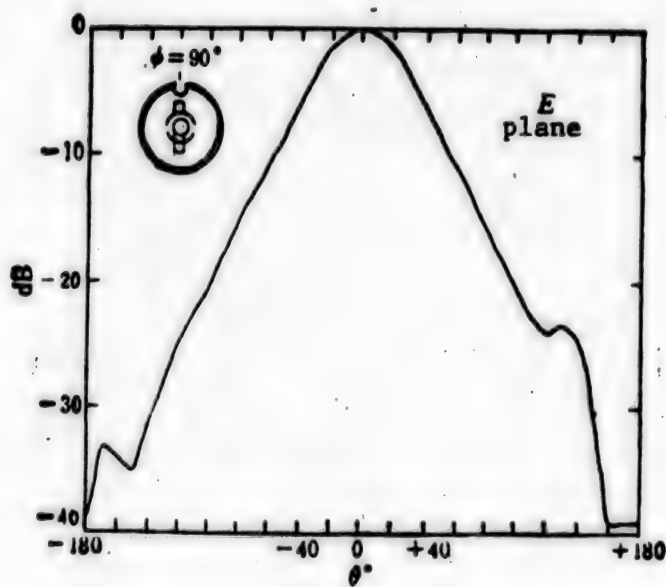
The conical-scanning auto-tracking parabolic antenna used in this feed source is shown in Figure 7. The antenna aperture  $D = 1.5$  m and the focal length  $F = 0.45$  m. Figure 8 shows the measured values of the antenna directional plots at a frequency of 1680 MHz.

The H plane's other secondary lobe has a  $P/P_{\max} \leq 0.02$  (-17 dB or less) and the E-plane secondary lobe has a  $P/P_{\max} \leq 0.0025$  (-26 dB or less). These secondary lobes almost overlap the horizontal axis, so they are not illustrated in Figure 8.



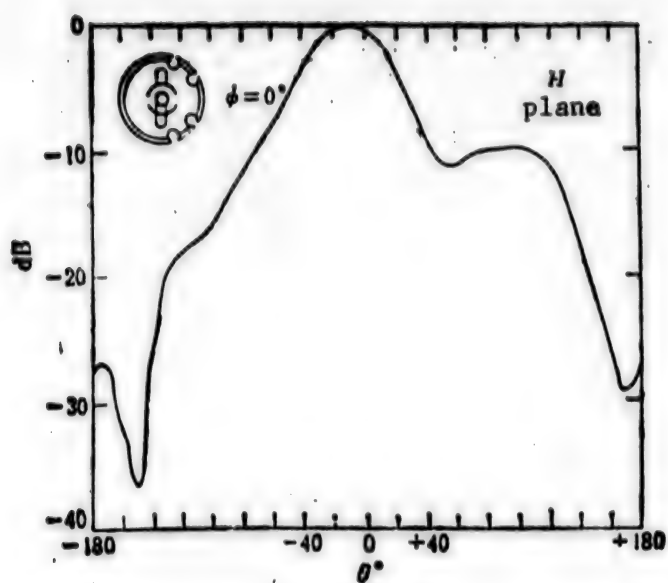


(a)

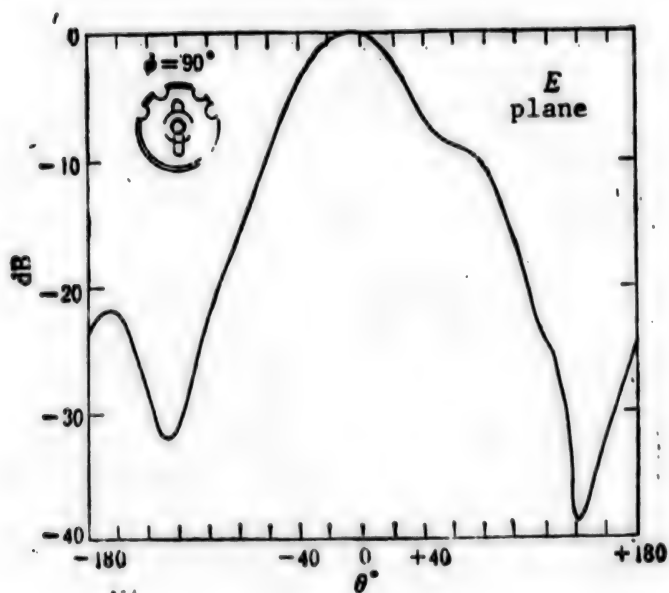


(b)

Figure 5. Directional Plot of Feed Source With a Single Slot and Hole



(a)



(b)

Figure 6. Directional Plot of Feed Source With Four Slots and Holes

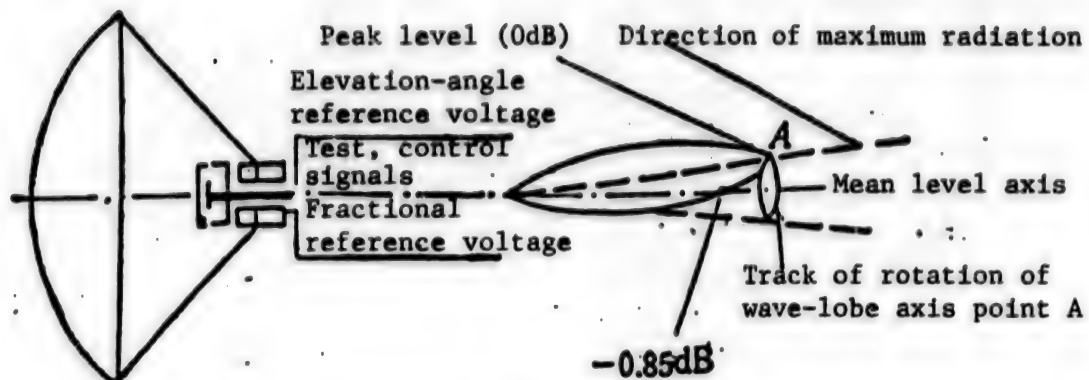


Figure 7. Diagram of Antenna

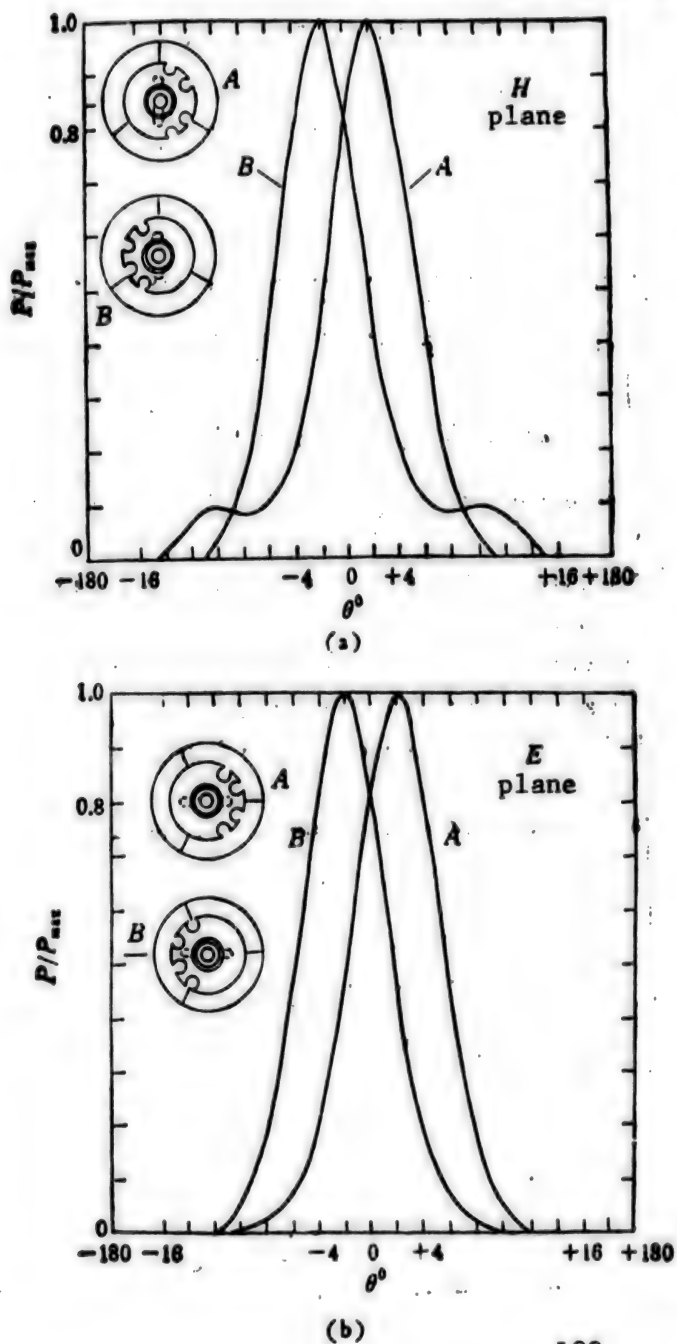


Figure 8. Directional Plot of Antenna

## V. Conclusion

This project involved experimental measurement and qualitative analysis for a conical-scanning auto-tracking antenna without a nutating feed source. The experimental results and qualitative analysis were consistent and can be used as references for engineering design. Static and dynamic tracking experiments were conducted. When tracking a moving target (a balloon), the antenna attitude was stable, the target was acquired quickly and accurately, and the tracking results were satisfactory.

China has not developed nutating feed sources. Other countries have them, but they have extremely complex structures and structural stability is hard to maintain during long-term use. Thus, the feed source substituted for the nutating feed source has obvious advantages in economy and stability.

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## Power Distribution of Backfire Helical Antenna, Applications

40080052d Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese  
Vol 10 No 5, Sep 88 pp 449-453

[Article by Ying Zhinong [2019 1807 6593] and Yang Yuan [2799 3220] of the Beijing Institute of Posts and Telecommunications: "Research on the Directionality of Backfire Model Helical Antennas and Their Applications"; manuscript received 6 Aug 86, revised 23 Mar 88]

[Excerpts] Abstract: This article surveys frequency-response theory for backfire-model helical antennas. We made assumptions about current traveling waves to obtain a far-field approximate analytical solution. The results conform basically with Nakano's numerical results. The authors used this theory to study the radiation characteristics of a new type of antenna with a backfire-model helix as a feed source and a conductive disk as a reflector. Results of real practical significance were obtained.

## I. Introduction

There has been a great deal of research on various types of helices,<sup>1,2</sup> but relatively little attention has been given to the Patton backfire-model helix.<sup>3</sup> Nakano recently made several advances in research using integral equation theory which indicate that this antenna can make an excellent feed source. On the basis of Nakano's figures, our project assumed a current distribution function to derive an approximately analytical solution for the antenna's far field to study the characteristics of this new type of backfire antenna.

## II. A Bilinear Backfire Helix

## A. Structure

Figure 1 shows the structure and coordinate system of the backfire helix. It is a type of bilinear-structure helix with a center symmetrical feed. The main direction of radiation is forward emission from the feed end out along the z axis. It is unlike the usual unilinear-axial-model helix and is known as a backfire helix. Its spatial structural functions and tangential vectors can be expressed as:

$$\vec{r} = z(-1)^n a \cos \phi' + y(-1)^n a \sin \phi' - za \phi' \tan \alpha \quad (1)$$

The tangential vector is

$$\hat{t} = -\hat{x} \sin \phi' \cos \alpha + \hat{y} \cos \phi' \cos \alpha + \hat{z} (-1)^{m+1} \sin \alpha \quad (2)$$

In each of these formulas, it is a right-branching helix when  $m = 0$  and a left-branching helix when  $m = 1$ . Their spatial position is symmetrical to the  $z$  axis. The parameters in the formulas are:  $\alpha$  is the helical angle,  $a$  is the helical radius, and  $\phi'$  is the polar-coordinate coiling angle variable.

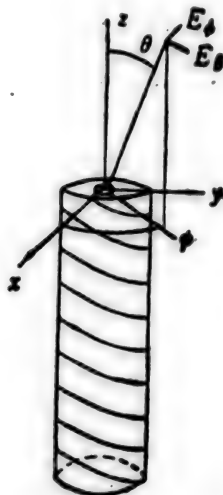


Figure 1. Backfire Helix Model Structure

#### B. Current Distribution

Nakano, Yamauchi, and others have used integral equation theory to solve the backfire-model helix structure.<sup>4,5</sup> Figure 2 shows their computed current distribution at various frequencies.<sup>5</sup> Nakano's computations indicate that the current weakens exponentially along the length of the axis toward the tip while the amplitude decreases with an increase in frequency. The current has a traveling-wave distribution, but it is a slow wave structure with a phase velocity that approximates the free-space phase velocity. In Figure 2, the helix cycle length  $C = 10$  cm, the helix angle  $\alpha = 12.5^\circ$ , and the center frequency is 2.6 GHz.

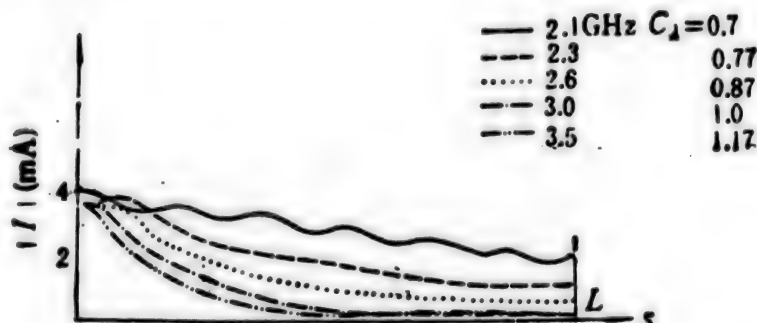


Figure 2. Changes in Current With Frequency



[Passage omitted]

#### D. Computed Results

Figures 4(a) and 4(b) show respectively, the directional plots computed from our approximate-solution analysis formula and the numerical solution using Nakano's method, assuming different values of  $C/\lambda$ . The regularities are similar. Foreward end emissions along the  $z$  axis are strongest around the center frequency. As the frequency rises, the half-power field angle increases and directionality decreases. This conforms to Nakano's experimental results.

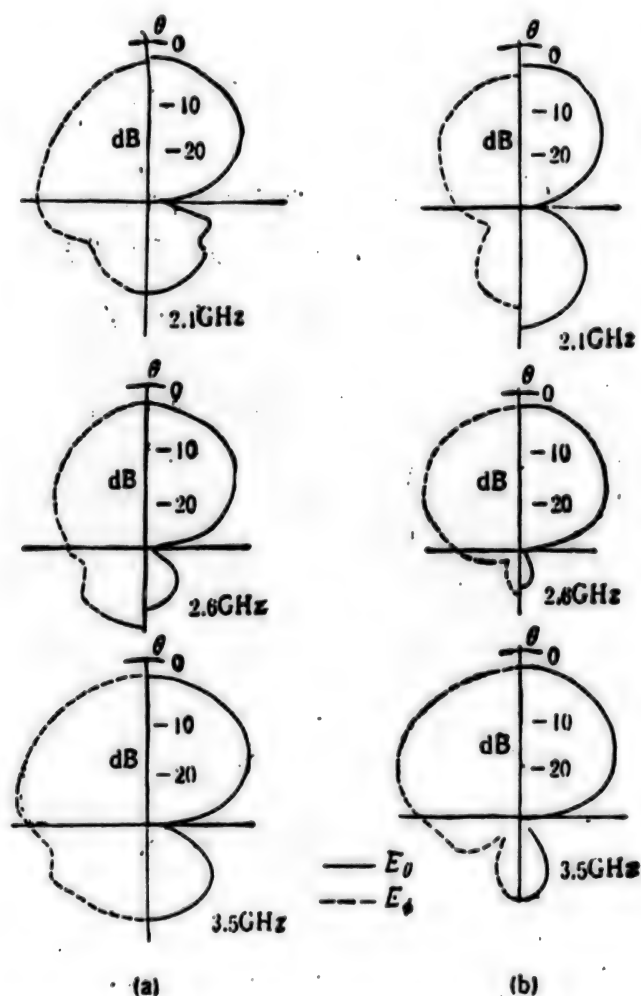


Figure 4. Radiation Directional Plot. (a) Approximate analysis solution; (b) Nakano's numerical solution

#### III. A Backfire Helix as a Reflector Antenna Feed Source

The backfire-model helix's structural simplicity, circular polarization, better frequency characteristics, moderate gain, and phase-center stability

make it an excellent feed source. This article suggests a structurally simple reflective antenna, shown in Figure 5.<sup>6</sup> The reflector is a disk, the normal line is parallel to the  $z$  axis, and the center of the disk is on the  $z$  axis, located at  $z_0 = 30$  cm, with a radius of 18 cm. The feed-source helix parameters are cycle length  $C = 10$  cm, helical angle  $= 12.5^\circ$ , and number of spirals  $N = 5$ .

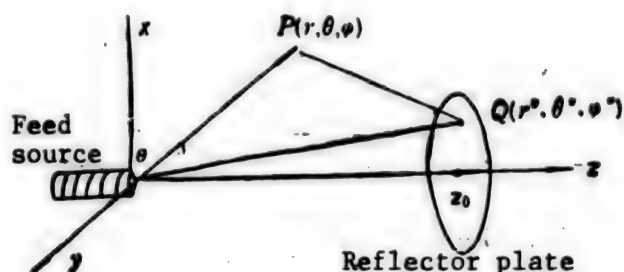


Figure 5. Simple Diagram of Reflector Antenna Structure

[Passage omitted]

We did calculations for this configuration at frequencies ranging from 1.5 GHz to 3.5 GHz. Figure 6 is a curve of directionality coefficients with changes in frequency. The maximum directionality coefficient  $D$  appears around  $f = 2.1$  GHz, where directionality is strongest. It declines as the frequency rises. Figure 7 shows directional plots at different frequencies. The results are satisfactory. The sidelobe leveling is very low at the center frequency and the directionality is stable over a very wide frequency band. It should be noted that changing the distance between the disk and the feed source also changes its radiation characteristics. This group of parameters was obtained via computer simulation and has real importance for guidance.

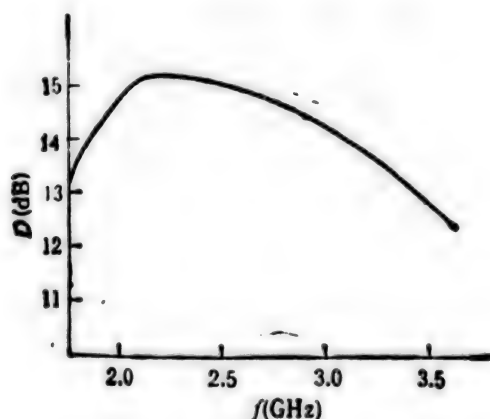


Figure 6. Directionality Coefficient Characteristics of the Simple Reflector Antenna

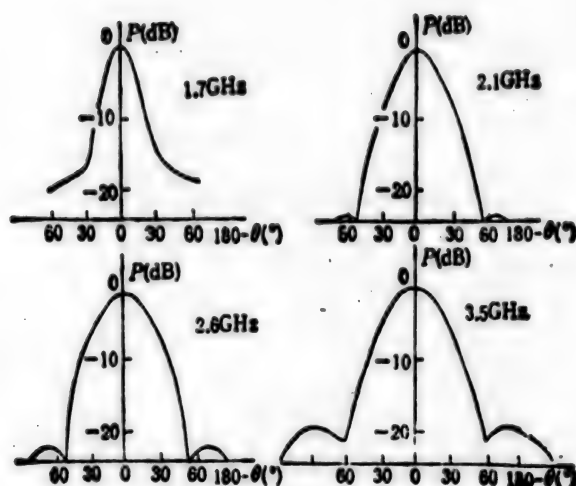


Figure 7. Directional Plot of Power for the Simple Reflector Antenna

#### IV. Conclusion

Our project studied the directionality of a backfire-model helix by deriving an approximately analytical result for its radiation field under assumed traveling-wave current conditions. A comparison with Nakano's numerical solution shows it to be basically identical. This article also suggests a new type of reflective antenna with a bilinear helix as a feed source and a conductive disk as a reflector. Equivalence theory was used to study its directionality. It was discovered that this antenna has a simple structure, moderate gain, and better frequency characteristics, and is easy to implement.

Comrade Zhong Guihua [6988 6311 5478] did some of the computations during our research, for which we are particularly grateful.

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# Error-Detection, Error-Correction Conditions for Resolving Range Ambiguities in Multiple PRF Pulse Doppler Radar

40080100a Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 16 No 6, Nov 88 pp 93-98

[Article by Dai Wenqi [2071 2429 3825], Wang Jialong [3769 1367 7127], and Zeng Jianyu [2582 1696 3842] (Zhejiang University, Hang Zhou) (manuscript received Apr 87, revised Aug 87)]

[Text] Abstract: In this article, the error-detection and error-correction conditions for resolving range ambiguities within the maximum detectable range of a multiple PRF [pulse repetition frequency] pulse doppler radar using the remainder theorem are presented. A multiple PRF radar which satisfies these conditions can achieve the same range measurement accuracy as a single PRF radar. The methods suggested are sufficiently simple to be used in real-time processing.

## I. Introduction

In a high or medium PRF pulse doppler radar, range ambiguities are created when the time delay of the target return is greater than the transmitted pulse repetition period. These range ambiguities can be resolved by transmitting multiple PRF and applying the (Chinese) remainder theorem.[1,2,3]

In practice, the effects of interference and noise and the relative motion between the radar and the target will cause significant error between the resolved range as calculated by the remainder theorem and the true target range. This article presents the conditions and methods for detecting and correcting such errors within the maximum detectable range of the radar. A multiple PRF radar with error-detection and error-correction capability can achieve the same range measurement accuracy as a single PRF radar.

## II. Error-Detection and Error-Correction Conditions and Methods

### 1. Induced Error $\Delta R$

Let the number of range cells contained in the  $k$ -tuple pulse repetition periods be  $m_1, m_2, \dots, m_k$  respectively, and let them be relatively prime; also, let the ambiguous ranges of the target be  $A_1, A_2, \dots, A_k$ , respectively.

In applying the remainder theorem to resolve range ambiguities, the true target range  $R^{[4]}$  can be obtained from the following expression:

$$R \equiv A_1 M_1 M'_1 + A_2 M_2 M'_2 + \dots + A_k M_k M'_k \pmod{M}$$

$$\triangleq \left( \sum_{i=1}^k A_i M'_i M_i \right)_M \triangleq \left( \sum_{i=1}^k A_i C_i \right)_M \quad (1)$$

where  $R$  and  $A_i$  are integers expressed in range cell units;

$$M = \prod_{i=1}^k m_i = m_1 M_1 = m_2 M_2 = \dots = m_k M_k, \quad (2)$$

$$(M'_i M_i)_{m_i} = 1, \quad i = 1, 2, \dots, k; \quad (3)$$

$$C_i = M'_i M_i, \quad i = 1, 2, \dots, k. \quad (4)$$

Let the true target range be  $R = 1$ ,  $A_1 = A_2 = \dots = A_k = 1$ , then from equation (1), one obtains:

$$\left( \sum_{i=1}^k C_i \right)_M = 1$$

i.e., 
$$\sum_{i=1}^k C_i = KM + 1, \quad K = 0, 1, 2, \dots \quad (5)$$

The maximum resolvable range using the remainder theorem is

$$R_{\max}' = \prod_{i=1}^k m_i - 1 = M - 1 \quad (6)$$

For most radars, the maximum detectable range satisfies the condition  $R_{\max} \ll M-1$ . If an error exists in the range measurement, then each of the measured ambiguous ranges  $A_i$  can be expressed as:

$$A'_i = A_i + \Delta A_i, \quad i = 1, 2, \dots, k$$

where  $\Delta A_i$  denotes the ambiguous range error in the  $i$ th PRF. From equation (1), the resolved range  $R'$  is

$$R' = \left( \sum_{i=1}^k A'_i M'_i M_i \right)_M = \left( \left( \sum_{i=1}^k A_i M'_i M_i \right)_M + \left( \sum_{i=1}^k \Delta A_i M'_i M_i \right)_M \right)_M$$

$$= (R + \Delta R)_M \quad (7)$$

where

$$\Delta R = \left( \sum_{i=1}^k \Delta A_i C_i \right)_M \quad (8)$$

$\Delta R$  is induced by a combination of range errors  $\Delta A_1, \Delta A_2, \dots, \Delta A_k$ . It is known from equation (4) that its value also depends on the number of range cells of the  $k$ -tuple PRF. Because the value of  $C_1$  given by equation (4) is generally quite large, a large  $\Delta R$  error will be introduced even if there is an error of only one range cell in the ambiguous range measurement; this results in a large deviation between the resolved target range and the true target range. For example, in a double PRF with ambiguous cells  $m_1 = 138, m_2 = 125$  and a range cell width of  $1 \mu s$ , one can calculate the values of  $C_1, C_2$  and  $M$  to be:  $C_1 = 6625, C_2 = 10626, M = 16250$ . If the target range is  $30 \text{ km}$ , then  $A_1 = 62, A_2 = 75$ . If the measured values of  $A_1$  and  $A_2$  are:  $A_1 = 62$  and  $A_2 = 76$ , i.e., the measured  $A_2$  has an error of one range cell, then the resolved range becomes  $R' = 1624 \text{ km}$ , or  $\Delta R = 1594 \text{ km}$ .

## 2. Distribution of $\Delta R$ Error

If the maximum allowable absolute error of each ambiguous range is  $N$ , and if the various values of  $\Delta A_i$  are all independent, then the set  $\Omega$  which contains different values of  $\Delta A_i$  has  $(2N+1)^k$  possible error combinations. It is known from equation (8) that the error combinations have a one-to-one correspondence with  $\Delta R$ ; let the projection of the set  $\Omega$  onto the error  $\Delta R$  be  $\Omega'$ .

(1) Let  $\Omega_0$  be a subset of  $\Omega$  which contains all identical range errors, i.e., in  $\Omega_0, \Delta A_1 = \Delta A_2 = \dots = \Delta A_k = n, |n| \leq N, A'_i = A_i + n, i = 1, 2, \dots, k$ , and the corresponding subset in  $\Delta R$  be  $\Omega'_0$ . From equation (5) we obtain:

$$R' = \left( \sum_{i=1}^k A'_i / C_i \right)_M = R + n, \quad \Delta R = n \quad (9)$$

where  $\Delta R$  is distributed in the integer range  $[-N, +N]$ , and any two adjacent  $\Delta R$  values differ only by 1. Thus, there are  $(2N+1)$   $\Delta R$  values in  $\Omega'_0$ , which includes a subset where all the ambiguous range errors are zero, and the corresponding  $\Delta R$  is also zero.

(2) Consider a subset of  $\Omega$  where the ambiguous range errors are not all identical; let an integer bias  $J$  be superimposed on each range error; i.e.,

$$\Delta A'_i = \Delta A_i + J, \quad A'_i = A_i + \Delta A'_i; \quad i = 1, 2, \dots, k$$

then

$$R' = \left( \sum_{i=1}^k (A_i + \Delta A_i + J) C_i \right)_M = (R + \Delta R + J)_M \quad (10)$$

$$\Delta R' = \Delta R + J \quad (11)$$

The value of  $\Delta R'$  due to the new error combination differs from the original  $\Delta R$  by only a small number  $J$ . Therefore, a subset  $\Omega_1$  of nonidentical ambiguous range combinations which satisfy equation (10) can be constructed within the set  $\Omega$ . The value of  $J$  in equation (11) is constrained by the maximum allowable absolute error  $N$ , i.e.,  $|\Delta A_i + J| \leq N, i = 1, 2, \dots, k$ ; therefore, the allowable range of  $J$  is given by:

$$-N - \min_i \Delta A_i \leq J \leq N - \max_i \Delta A_i \quad (12)$$



where  $\min_i \Delta A_i$ ,  $\max_i \Delta A_i$  denote the minimum and maximum values of  $\Delta A_i$  in a particular error combination respectively. From this expression, one can determine the number of possible integers  $J$  as:

$$P = 2N + 1 - (\max_i \Delta A_i - \min_i \Delta A_i) \quad (13)$$

where  $P$  denotes the number of values of  $\Delta R$  in the subset  $\Omega'_i$  in which the values of all adjacent elements differ by 1. Equation (13) also shows that  $P$  depends only on the maximum absolute error  $N$  and the difference between the maximum and minimum range errors in a particular combination; it is independent of the choice of which combination in the subset  $\Omega_i$ .

It follows that for any error combination in  $\Omega$  which satisfies the condition  $\min_i \Delta A_i = -N$ ,  $\max_i \Delta A_i = N$ ,  $i = 1, 2, \dots, k$ , then  $J = 0$ ,  $P = 1$ , hence this combination can form an independent subset. With the exception of this subset and the subset  $\Omega'_0$ , the number of  $\Delta R$  contained in all the other subsets  $\Omega'_i$  falls between 1 and  $(2N+1)$ .

(3) Consider any two combinations in  $\Omega$  whose ambiguous range errors are not identical; thus the differences between the corresponding range errors are not constant, i.e.,  $\Delta A'_i = \Delta A_i + J_i$ ,  $A'_i = A_i + \Delta A_i + J_i$ ;  $i = 1, 2, \dots, k$ . Therefore,

$$R' = \left( \sum_{i=1}^k (A_i + \Delta A_i + J_i) C_i \right)_M = \left( R + \Delta R + \left( \sum_{i=1}^k J_i C_i \right)_M \right)_M$$

$$\Delta R' = \Delta R + \left( \sum_{i=1}^k J_i C_i \right)_M \quad (14)$$

Since the values of  $C_i$  are large, in general the value of  $\Delta R'$  differ substantially from the value of  $\Delta R$ . Hence the two combinations do not belong to the same subset  $\Omega_i$ .

(4) The set  $\Omega$  contains  $(2N+1)^k$  error combinations and the set  $\Omega'$  has an equal number of  $\Delta R$ . The number of  $\Delta R$  in the subset  $\Omega'_0$  and in most subsets is greater than 1; therefore, the number of subsets  $\ell$  contained in  $\Omega$  is less than  $(2N+1)^k$ .

Based on the above discussion, the  $\Delta R$  set  $\Omega'$  can be divided into several subsets  $\Omega'_i$ , of which  $\Omega'_0$  is a subset in the neighborhood where  $\Delta R = 0$ . Within the same subset, the values of adjacent  $\Delta R$  only differ by 1, but the values of  $\Delta R$  in different subsets generally are substantially different. For example, in the case of ambiguity resolution using triple PRF, if  $N = 1$ ,  $\Omega'$  can be divided into 18 subsets, and the  $\Delta R$  distribution is shown in Figure 1.

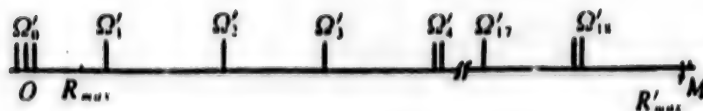


Figure 1.  $\Delta R$  Distribution for  $k = 3, N = 1$

### 3. Conditions for Error Detection and Error Correction

Let all subsets in  $\Omega'$  be ordered according to the values of  $\Delta R$ , and let the maximum and minimum values of  $\Delta R$  in subset  $\Omega'_j$  be denoted by  $\Delta R_{\max, j}$  and  $\Delta R_{\min, j}$  respectively, then

$$\Delta R_{\max, j} < \Delta R_{\min, j+1}, \quad j=0, 1, 2, \dots, l-1 \quad (15)$$

$$\Delta R_{\max, j} - \Delta R_{\min, j} \leq 2N+1, \quad j=0, 1, 2, \dots, l \quad (16)$$

The subset  $\Omega_0$  is a special case with small  $\Delta R$ ; the combinations in  $\Omega_0$  with identical range errors can be considered to be essentially free of error.

In the remaining subsets  $\Omega_j$ , if their  $\Delta R > R_{\max}$  and  $\Delta R < (M - R_{\max})$ , then the resolved range  $R'$  of any ambiguous range where error occurs would exceed  $R_{\max}$ ; hence this leads to the following conditions for detecting the presence of error:

$$\Delta R_{\min, i} > R_{\max} \quad (17)$$

$$\Delta R_{\max, i} < M - R_{\max} \quad (18)$$

Under the conditions (17) and (18), equation (7) can be rewritten as:

$$R' = R + \Delta R \quad (19)$$

The next step is to correct the error by removing the  $\Delta R$  embedded in the resolved  $R'$  to obtain the true target range. To perform error correction, it is necessary to identify from  $R'$  the subset  $\Omega'_j$  which contains  $\Delta R$ . The subset  $\Omega'_j$  which contains a given error combination can be uniquely determined only when the closest distance between two adjacent subsets is greater than the maximum detectable range of the radar  $R_{\max}$ . Therefore, the condition for error detection is

$$\Delta R_{\max, i} + R_{\max} < \Delta R_{\min, i+1} \quad i=0, 1, 2, \dots, l-1 \quad (20)$$

Since the  $\Delta R$  set  $\Omega'$  is completely determined by the number of range cells in the  $k$ -tuple PRF  $m_1, m_2, \dots, m_k$  and  $N$ , the PRF waveform parameters should be designed such that for given  $R_{\max}$  and  $N$ , the number of range cells must satisfy the conditions (17), (18), and (20). In practice, these conditions for error detection and error correction are easily satisfied.

If the selected multiple PRF parameters satisfy the error detection and error correction conditions, then an error in the ambiguous range can be

removed by determining the subset  $\Omega'_j$  which corresponds to this error combination. Subtracting from  $R'$  the central value  $r_j$  of  $\Delta R$  in this subset yields a value  $R_T$  which closely approximates the true target range:

$$R_T = R' - r_j \quad (21)$$

where  $r_j = \frac{1}{2}(\Delta R_{\max,j} + \Delta R_{\min,j})$ ,  $j = 1, 2, \dots, l$ , is called the correction number. The maximum residual error  $\delta_j$  after correction is determined by the maximum and minimum values of  $\Delta R$  as follows:

$$\delta_j = \frac{1}{2}(\Delta R_{\max,j} - \Delta R_{\min,j}), \quad j = 1, 2, \dots, l \quad (22)$$

Since all adjacent  $\Delta R$  values differ by 1, one can obtain from equation (13):

$$\delta_i = N - \frac{1}{2}(\max_i \Delta A_i - \min_i \Delta A_i) \leq N, \quad i = 1, 2, \dots, l \quad (23)$$

Therefore, multiple PRF with error detection and error correction capability can achieve the same range measurement accuracy as single PRF.

The above analysis shows that once  $R'$  is determined, the following procedure can be used for error correction:

- (1) If  $R' < r_1$ , then it is known from equation (20) that  $\Delta R$  belongs in the subset  $\Omega'_0$ , and no error correction is required. The target range  $R_T = R'$ , and the range measurement accuracy is  $\Delta = |R' - R| = N$ .
- (2) If  $r_i < R' < r_{i+1}$ ,  $i = 1, 2, \dots, l-1$ ; then  $\Delta R$  belongs in the subset  $\Omega'_i$ , and the corrected range is  $R_T = R' - r_i$ ,  $\Delta \leq \delta_i$ .
- (3) If  $R' > r_l$ , then  $\Delta R$  belongs in the subset  $\Omega'_l$ , and the corrected range is  $R_T = R' - r_l$ ,  $\Delta \leq \delta_l$ .

### III. Analysis of Error Detection and Error Correction for Double and Triple PRF Range Measurement

Because of the existence of velocity and range blind regions and the fact that the maximum detectable range of radar is much smaller than  $R'_{\max}$ , in general multiple PRF waveforms are transmitted to improve the radar's range measurement capability; in particular, double or triple PRF is used to resolve range ambiguities. If the range error of double PRF does not exceed a range cell, i.e.,  $|\Delta A_1| \leq 1$ ,  $|\Delta A_2| \leq 1$ , then there are nine possible values of  $\Delta R(\Delta A_1, \Delta A_2)$ :

- (1)  $\Delta R(0, 0) = 0$
- (2)  $\Delta R(+1, +1) = (C_1 + C_2)_M = 1$
- (3)  $\Delta R(-1, -1) = (-C_1 - C_2)_M = -1$

- (4)  $\Delta R(-1, 0) = (-C_1)_M = C_1 - 1$
- (5)  $\Delta R(0, +1) = (C_2)_M = C_2$
- (6)  $\Delta R(+1, 0) = (C_1)_M = C_1$
- (7)  $\Delta R(0, -1) = (-C_2) = C_2 - 1$
- (8)  $\Delta R(-1, +1) = (-C_1 + C_2)_M$
- (9)  $\Delta R(+1, -1) = (C_1 - C_2)_M$

The first three error combinations belong in the subset  $\Omega_0$ , where the error in the resolved target range does not exceed one range cell. In the remaining six error combinations,  $C_1 - 1$ ,  $C_1$  and  $C_2 - 1$ ,  $C_2$  each belongs in a different subset; hence there are four subsets of error combinations that require correction:  $\Omega_1, \Omega_2, \Omega_3, \Omega_4$ . Let the corresponding correction numbers be  $r_1, r_2, r_3$ , and  $r_4$ , respectively, and the maximum residual error be  $\delta_1, \delta_2, \delta_3, \delta_4$ . Then from equations (17) and (18), the error detection conditions are:

$$\left. \begin{array}{l} \min(C_1 - 1, (-C_1 + C_2)_M, C_2 - 1, (C_1 - C_2)_M) > R_{\max} \\ \max(C_1, (-C_1 + C_2)_M, C_2, (C_1 - C_2)_M) < M - R_{\max} \end{array} \right\} \quad (24)$$

From equation (20), the error correction conditions are:

$$\left. \begin{array}{l} R_{\max} + 1 < r_1, \quad R_{\max} + r_2 + \delta_2 < r_3 - \delta_3 \\ R_{\max} + r_1 + \delta_1 < r_2 - \delta_2, \quad R_{\max} + r_3 + \delta_3 < r_4 - \delta_4 \end{array} \right\} \quad (25)$$

A similar analysis can be carried out for triple PRF, but it will not be described in this article.

**Example 1:** Consider range ambiguity resolution using double PRF, with  $m_1 = 138$ ,  $m_2 = 125$ ,  $R_{\max} = 2000$  (if the width of the range cell is  $1 \mu s$ , the maximum detectable range is 300 km),  $|\Delta A_1|, |\Delta A_2| \leq N = 1$ .

**Solution:** The calculated results are:  $M = 17250$ ,  $C_1 = 6625$ ,  $C_2 = 10626$ ,  $r_1 = 4001$ ,  $r_2 = 6624.5$ ,  $r_3 = 10625.5$ ,  $r_4 = 13249$ ,  $\delta_1 = 0$ ,  $\delta_2 = 0.5$ ,  $\delta_3 = 0.5$ ,  $\delta_4 = 0$ . From equations (24) and (25), we know that the double PRF parameters satisfy the error detection and error correction conditions. Hence, the target range can be resolved to an accuracy of one range cell.

If the true target range is 30 km, i.e.,  $R = 200$ ,  $A_1 = 62$ ,  $A_2 = 75$ , and the measured ambiguous ranges are  $A'_1 = 62$ ,  $A'_2 = 76$ , then from equation (7) one can obtain  $R' = 10826$ . Since  $r_3 < R' < r_4$ , the corrected target range is  $R_T = R' - r_3 = 200.5$ , hence the range error is only 0.5

**Example 2:** Consider range ambiguity resolution using triple PRF, with  $m_1 = 83$ ,  $m_2 = 97$ ,  $m_3 = 109$ ,  $R_{\max} = 1000$  (if the width of the range cell is  $1 \mu s$ , then the maximum detectable range is 150 km),  $|\Delta A_1|, |\Delta A_2|, |\Delta A_3| \leq N = 2$ .

Solution: The calculated results are:  $C_1 = 137449$ ,  $C_2 = 506632$ ,  $C_3 = 233479$ ,  $M = 877559$ . Again from equations (17), (18) and (20), we know this set of PRF parameters satisfy the error detection and error correction conditions.

If the true target range corresponds to  $R = 1000$ , i.e.,  $A_1 = 4$ ,  $A_2 = 30$ ,  $A_3 = 19$ , and the measured ambiguous ranges are  $A'_1 = 6$ ,  $A'_2 = 28$ ,  $A'_3 = 20$ , then the resolved range  $R' = 373672$ , and the corresponding correction number is  $r_1 = 372672$ ; hence the corrected target range is  $R_T = R' - r_1 = 1000$ , and the range error is 0.

#### IV. Concluding Remarks

The error-detection and error-correction conditions suggested in this article for resolving range ambiguities using the remainder theorem can be easily satisfied by multiple PRF waveforms. In the design of a multiple PRF pulse doppler radar, it is possible to select the waveform parameters to provide both near-optimum measurement performance and error-detection and error-correction capabilities. As a result, the large deviation in the resolved range caused by ambiguous range errors can be eliminated and a measurement accuracy comparable to that of single PRF can be achieved.

In practical applications, the ambiguous range often produces only a one-range-cell error, hence the range measurement accuracy is also one range cell; and the number of correction numbers is quite small. The correction numbers can be pre-calculated and stored in ROM; the correction process is very simple, and can be implemented in real-time by using a table look-up procedure.

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Large Barium Titanate Crystals Developed

40080116b Beijing RENMIN RIBAO in Chinese 7 Dec 88 p 3

[Article by Chen Zujia [7115 4371 3946]]

[Text] Beijing, 6 Dec--Displayed in a glass box are some light yellow crystals; they are the large barium titanate crystals recently developed by researchers in the Institute of Physics of the Chinese Academy of Sciences (CAS).

This morning, along with a group of experts, this reporter had the opportunity to see a demonstration of the application of these crystals in a laboratory of the Institute of Physics. A laser beam passing through a slide produced the image of a young girl's head on the wall. When the beam was interrupted by a piece of glass, the image was distorted and became fuzzy. Under the action of the barium titanate crystal, the distorted image gradually cleared, even to the detail of threads of hair. Researchers explained that this was like looking into a mirror through a water-vapor-fogged glass; the image was unclear. If the mirror is replaced by a barium titanate crystal, then the image seen through the same glass becomes clear. In optics this is known as restoration from distortion. It was said that such crystals can also amplify a weak optical signal. Devices made of barium titanate crystals can be used in optical image recognition, optical signal processing, optical computing and optical communications.

Barium titanate is currently the most interesting optical refraction material in the world. Although researchers have grown barium titanate crystals since the 1950's, the crystals were small platelets on the order of 1 millimeter in size. In the 1970's, 10-to-20-mm crystals were grown by American and French scientists, but crystals were only available from one company on the international market: (Sen-de) Company of the United States, and were therefore in short supply.

In less than 2 years, researchers of CAS's Institute of Physics solved key problems in the growth of barium titanate crystals and obtained a batch of crystals. Their sizes reach 25x10 square millimeters and the quality is state-of-the-art. These crystals have also been exported to Europe, the United States and Japan. This achievement was appraised favorably by an evaluation committee chaired by Wang Daheng [3769 1129 3801] of the CAS's Scientific Council.



**L-Arginine Phosphate Crystals Developed--New Nonlinear Material for Laser Fusion**

40080116c Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 21 Jan 89 p 4

[Excerpts] A new nonlinear optical material, L-arginine phosphate (LAP) crystals, won first prize at the 1988 National Invention Awards.

In the rapid development of the new-technology revolution, there is a need for various new optoelectronic materials. For example, laser fusion requires short-wavelength, high-energy, high-coherency light sources. Therefore, materials scientists are diligently seeking ultraviolet nonlinear optical crystals that have a high conversion efficiency, large transmission cross-section, and high optical damage threshold. [Passage omitted]

Nonlinear optical crystals can be divided into two classes. One class is water soluble, such as KDP [potassium dihydrogen phosphate] and ADP [ammonium dihydrogen phosphate]. Although they can be grown into large homogeneous single crystals and have reasonably high damage thresholds, their nonlinearity coefficients are generally low and their moisture resistance is poor. The other class is crystals grown under high temperature, such as  $\beta$ -BBO [beta barium borate] and KTP [potassium titanyl phosphate,  $\text{KTiOPO}_4$ ]. Although their nonlinearity coefficients are high and they have good damage thresholds, it is exceedingly difficult to obtain single crystal elements greater than 100mm in diameter. Their applications are therefore very limited.

Laser frequency-conversion materials with large area, large cross-section, high efficiency, and high damage threshold are urgently needed in research, defense, energy and medicine.

At Shandong University, Xu Dong [6079 2639], Shao Zongshu [6730 1350 2579], Jiang Minhua [5592 3046 5478], and Tan Zhongke [6223 1813 1870] have long been engaged in the development of new ultraviolet nonlinear crystals. They found that research on water-soluble nonlinear crystals has been very active in recent years. Most of the efforts are concentrated in two types of crystals: aromatic organic crystals with large conjugate  $\pi$  bonds and inorganic crystals with oxygen polyhedral structures. However, these crystals cannot satisfy the simultaneous requirements of high optical

nonlinearity and high transmissivity in the ultraviolet [region]. Urea is a good nonlinear organic crystal for ultraviolet radiation, but its extremely poor resistance to moisture limits its use. After studying crystal properties, microscopic elements, and the relationship between structures for many years, Xu Dong and his colleagues selected a combination of an organic conjugate molecular group and inorganic oxygen polyhedrons and made use of their aligned structure in solving the problem with organic crystals. They improved the nonlinearity coefficient and extended the transmission band for UV light. They succeeded in developing a new material--the L-arginine phosphate (LAP) crystal. The LAP crystal is superior to KDP and can be used in the frequency conversion of ultraviolet, visible, and near-infrared laser light. The crystals have large cross-sectional area, a high efficiency and a high damage threshold.

LAP crystals are known internationally as a superior ultraviolet nonlinear optical material first developed by Chinese experts. They are moisture resistant and have an extremely high optical damage threshold and a high nonlinearity coefficient. They can be easily grown into large optical-quality single crystals, ideal for laser fusion and other uses.

Soon after the release of part of the invention in 1983, LAP crystals immediately caught the attention of researchers here and abroad. This type of crystal was regarded by the American nonlinear optics community as one of the four most promising types in the world. It is expected to replace KDP in laser fusion and other important applications. Many companies and universities in the United States and Japan wrote or sent people to request for information or to purchase the crystals. This invention has already been used in instruments and products of Institute No 11 of the Ministry of Electronics Industry, the Beijing Optoelectronic Technology Institute, and the Jinan Optical-Protection Products Plant, and has generated considerable economic benefits.

High-Energy Ion Implanter Passes Evaluation

40080127b Beijing ZHONGGUO DIANZI BAO in Chinese 10 Jan 89 p 1

[Article by Liu Dong [0491 2639]: "Institute No 48 of the Ministry of Machine-Building and Electronics Industry Wins National S&T Development Project"]

[Text] The LC-4 high-energy ion implanter developed by Institute No 48 of the Ministry of Machine-Building and Electronics Industry passed its evaluation in Beijing on 28 December 1988, signifying that yet another major national research project has been successfully concluded.

The LC-4 high-energy ion implanter was a state-allocated major scientific research project. The machine will provide an important means for researching new ICs, light-emitting devices, optical receivers, chemical-compound semiconductor devices, and magnetic devices, and for seeking new luminous materials, magnetic materials, semiconductor materials, metallic materials, and superconducting materials.

The maximum energy reached with this machine is 750 KeV, making it the highest-energy implanter in China at present, and it is the first ion implanter in China having dual tubes and dual target chambers, as well as a filter for harmful gasses. The beam-parameter for this machine is at the forefront of similar ion implanters throughout the world today.

The LD-1 ion-beam thin-film deposition machine developed by Institute No 48 of the Ministry of Machine-Building and Electronics Industry passed its technical evaluation at the same time. It is the first machine of its type to be put into applied production in China.

New Advances Announced in Ion-Beam Deposition

40080127c Beijing ZHONGGUO DIANZI BAO in Chinese 27 Jan 89 p 3

[Article by Li Qiongrui [2621 8825 3843]: "New Gains in Ion-Base Aided Deposition Technology"]

[Text] The applied research begun by the Beijing Institute of Motion-Picture Machinery on ion-beam-aided deposition (IAD) techniques has recently resulted in new achievements. The institute used its independently designed and constructed LY-1 ion source and the IAD technique to prepare a narrow-band optical filter and a metallic film-layer protection film for depositing single-layer and multiple-layer anti-reflection films, variable density films, and spectral films on glass and CR-39 plastic substrate.

IAD is used to deposit thin films because of such outstanding characteristics as greatly improved thin-film quality, as for example with adherence, wear resistance, humidity resistance, corrosion resistance, and thin-film stability, which doubles its favor with thin-film workers. This technology has become a major topic of research in the thin-film industry at present both in China and abroad.

An ion source is the basis of the IAD technique, and the ion-beam energy of the LY-1 ion source developed by this institute may be adjusted in the range 50-1,200 ev [sic]. Overall beam current is 0-120 mA, and oxygen ions may be continuously generated for 3 hours and more; also, the anode and cathode constitute an independent component, which aids in cleaning and replacement. In addition to its use in the IAD technique, the machine is also suitable for ion etching, as in replication of optical gratings.

Experimental Research on Measurement of Optical Fiber Bandwidth

40080046a Shanghai DIANZI JISHU [ELECTRONIC TECHNOLOGY] in Chinese Vol 15  
No 8, Aug 88 pp 5-6

[Article by Zhu Sichi [2612 0934 3069] and Yan Aimin [7051 1947 3046] of the  
Wuhan Institute of Posts and Telecommunications Science]

[Text] I. Introduction

Continual improvements in fiber optic manufacturing technologies and applications requirements have made rapid and reliable measurement of the transmission bandwidth of optical fibers an urgent issue. The most common method at present is to measure the pulse response of an optical fiber as a basis for using an empirical formula to estimate its transmission bandwidth. Another one is the frequency domain method, which uses a sweep frequency device or tracking oscilloscope for rapid display of the frequency spectrum plot of fiber optic response. Conventional determinations are then used, such as determining the corresponding fiber optic bandwidth for an amplitude dropoff of 6 dB (electrical). Because the designed refractive cross section of an optical fiber is often less than the optimum value, distortion of various shapes can appear in the pulse response waveform (foreground steps, background steps, dual peaks, etc.). These can cause substantial variations in results obtained by different units with different measurement methods, and some results are hard to accept. This causes many problems in comparing measured results from different units and in extending and applying their optic communications. We used measurement experience accumulated over several years and, luckily, found fiber optic samples exhibiting all types of distortion needed during several optical fiber bandwidth tests. In addition, we did experiments in two established measurement systems and then did categorical analysis to find the source of difference between measurements made using the time-domain and frequency-domain methods. The results obtained using these two measurement methods enabled us to deal with problems which have not been clearly understood for years. We now will describe how we used the time-domain and frequency-domain methods for experimental measurement of optical fiber bandwidth.

## II. Measurement Principles and Equipment

The basic principle in using the time-domain method to measure fiber optic bandwidth is that a very narrow light pulse is transmitted into the input end of the fiber being measured. The pulse waveform output after transmission through the fiber is examined at the output end of the fiber. The output pulse waveform is compared with the input pulse waveform, allowing derivation of the bandwidth of the optical fiber being measured.

Figure 1 shows the measurement equipment. The pulse signal generated by the signal source is modulated onto the DC-biased LD [laser diode], causing it to generate a light pulse signal. The light signal is converted into an electrical signal after transmission through the fiber, displayed on an oscilloscope, and recorded.

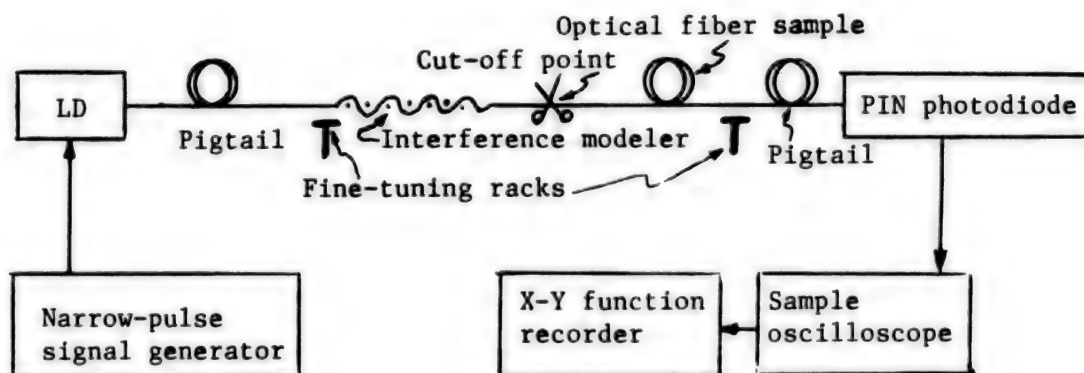


Figure 1: Equipment for Using the Time-Domain Method to Measure Optical Fiber Bandwidth

The formula for estimating bandwidth is:

$$B = \frac{0.44}{\sqrt{\tau_2^2 - \tau_1^2}} (\text{GHz}) \quad (1)$$

The basic principle involved in using the frequency-domain method to measure fiber optic bandwidth is that, from the perspective of the optical power being transmitted, it is possible to consider the optical fiber network to be an optical power quasi-linear network, so the fiber's transmission function  $H(\omega)$  [lower-case omega] is:

$$H(\omega) = F_2(\omega) / F_1(\omega) \quad (2)$$



In the formula,  $\omega$  is the bandwidth modulation frequency, and  $F_1(\omega)$  and  $F_2(\omega)$  are, respectively, the frequency spectrum of the signal before and after transmission through the fiber.

$H(\omega)$  includes amplitude and phase signals. Only the amplitude signal of the optical fiber transmission function is obtained using the conventional frequency-domain method, thus

$$|H(\omega)| = |F_2(\omega)/F_1(\omega)| \quad (3)$$

Usually, the modulation frequency at which the change in  $|H(\omega)|$  with  $\omega$  drops to  $1/2 |H(0)|$  is defined as the fiber bandwidth.

The testing equipment is shown in Figure 2. The continuously variable frequency sinusoidal signal generated by the signal source is modulated onto the DC-biased LD, causing it to generate a sinusoidally modulated light signal with a continuously variable frequency. The amplitude characteristics of this signal before and after passing through the optical fiber are measured and recorded. This provides the transmission baseband frequency bandwidth of the fiber being measured.

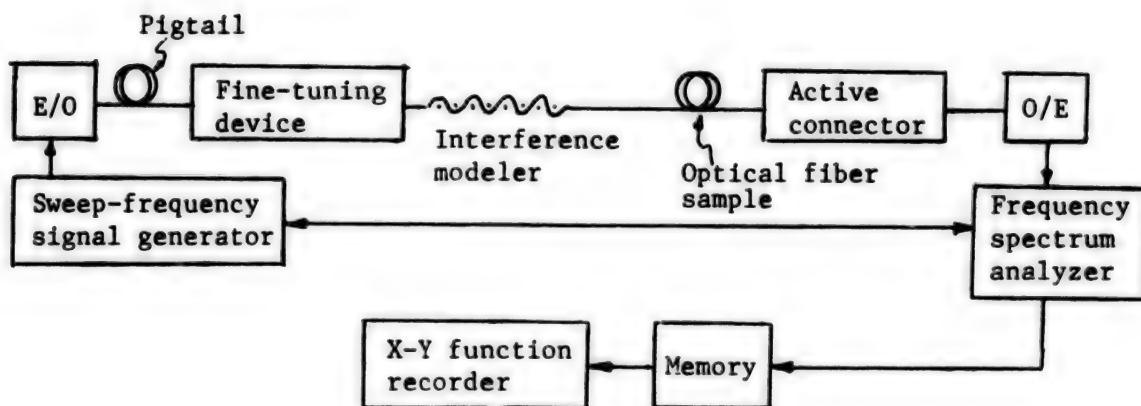


Figure 2: Equipment for Using the Frequency-Domain Method to Measure Optical Fiber Bandwidth

### III. Experimental Results and Discussion

We used equipment employing these two measurement methods to make experimental measurements on preselected optical fiber samples exhibiting different distortion shapes. The experimental results are shown in Tables 1, 2, 3, and 4.

Table 1. Experimentally Measured Results

Optical fiber catalog #	Length (m)	Freq.-domain measured values (MHz·km)	Time-domain measured values (MHz·km)	Shape of distortion
MG-38A	1600	>1000	>1000	Gaussian distribution
MF-30A	1752	>1000	>1000	
MF-28A	1980	>1000	>1000	
MF-17B	1230	>1000	>1000	
ML-29B	1913	>1000	>1000	
MY-32A	844	>1000	>1000	

Table 2. Experimentally Measured Results

Optical fiber catalog #	Length (m)	Freq.-domain measured values (MHz·km)	Time-domain measured values (MHz·km)	Shape of distortion
MY-51A	1692	330	348	Dual peaked
MY-42A	2773	249	224	
ML-23B	1140	285	273	
MF-3B	2329	349	339	

Table 3. Experimentally Measured Results

Optical fiber catalog #	Length (m)	Freq.-domain measured values (MHz·km)	Time-domain measured values (MHz·km)	Shape of distortion
MF-44A	1316	357	748	Foreground step less than half value
Stone C-215(I)	1535	307	296	Foreground step more than half value
ML-27B	1890	570	>1000	Foreground step less than half value
MY-83	2250	506	912	Foreground step less than half value

Table 4. Experimentally Measured Results

Optical fiber catalog #	Length (m)	Freq.-domain measured values (MHz·km)	Time-domain measured values (MHz·km)	Shape of distortion
DD-61	2084	313	325	Background step more than half value
MY-2A	2350	505	948	Background step less than half value
DE-68	1717	343	617	Background step less than half value
MF-21A	1100	590	985	Background step less than half value

The experimental results in Tables 1, 2, 3, and 4 show a rather good fit between the optical fiber bandwidths obtained by the time-domain and frequency-domain methods when the pulse spreading waveform of the light pulse has an ideal Gaussian waveform after transmission through the fiber. When a foreground or background step occurs in the pulse spreading waveform of the light pulse after transmission through the optical fiber, the results obtained using the two measurement methods vary. The size of the difference is related to the height of the step. If the step amplitude exceeds one half of the maximum pulse amplitude, the results of the two measurement methods are rather close. If the step amplitude is less than one-half the maximum amplitude, there is an obvious difference in the results of the two measurement methods. Obviously, the bandwidth estimation formula in the time-domain method cannot be used to calculate the bandwidth of the fiber being measured, so the estimated coefficient in the formula must be corrected. Our experience in experiments over several years indicates that when the pulse spreading waveform has a non-Gaussian distribution after transmission through the fiber, the estimated coefficient from formula (1) must be determined based on the height of the step in the waveform. The higher the step, the lower the assumed value of the coefficient. At a step amplitude greater than one-half the maximum amplitude, it can be handled as a nearly Gaussian distribution and the estimated coefficient can still be assumed to be 0.44. The reason is that the effects of the step are included when reading the  $\tau$ [lower-case tau]<sub>2</sub> value. This is evident in the experimental results in Tables 3 and 4.

All pulse responses of the fiber optic samples shown in Table 2 have dual-peak waveforms. Formula (1) also cannot be used to calculate the bandwidth of this group of optical fiber samples, and the coefficient in the formula must be corrected during the calculations. Similar results were obtained using the two measurement methods. We feel that this is due mainly to taking into account the effects of the dual peaks when reading  $\tau$ [lower-case tau]<sub>2</sub> using the time-domain method. In the frequency-domain method, however, a dual peak in the output pulse waveform attenuates the baseband response curve very

quickly in the low-frequency segment, but attenuation is slower in the middle and high frequency segments, or the decline of the entire curve may not be monotonal but instead may have several inflections in the middle, that is, there may be two frequency values which correspond to a specific attenuation value. Usually, the lowest frequency value is chosen in this situation, meaning that the worst-case scenario is taken into consideration.

Everyone knows that the fiber optic refractive cross section exponent  $\alpha$  [lower-case alpha] plays a primary role in the light scattering properties of optical fibers. When  $\alpha$  is the optimum value, the transmission-made group delay in the optical fiber is at a minimum and the output waveform has a Gaussian distribution and only rather small spreading. The fiber-optic samples listed in Table 1 belong to this category of fibers. In contrast, if  $\alpha$  is not the optimum value, the effects of excessive or inadequate high-order-mode compensation, mode coupling during transmission, and other things may increase the intermodal group delay and permit spreading waveforms with various shapes of distortion (foreground steps, background steps, dual peaks, etc.) to appear. The sample optical fibers chosen for Tables 2, 3, and 4 belong to this category. This type of optical fiber was fairly common during the early period of fiber manufacture. Now, multimode fiber-optic manufacturing technologies are basically mature and there is a decreased incidence of this type of optical fiber. They are encountered frequently in conventional testing, however, so we suggest that analysis be done according to concrete situations when using different methods to measure these fibers, with the proper corrections. Otherwise, different measurement methods will produce different results for the same fiber, sometimes considerably different, making it hard for various units to obtain the same results.

Generally speaking, the equipment used in time-domain method measurements is simple and provides a direct view. However, the transmitted pulse must be sufficiently narrow and the range of bandwidth measurement restricted, and the effects of the pulse response waveform will be rather large. The frequency-domain method directly provides a baseband frequency characteristics curve for the fiber being measured. The high-frequency-region signal/noise ratio will not be as low as with the time-domain method and linearity problems with the testing devices can be handled better than with the time-domain method. During actual measurements, the frequency-domain method is used more often for the measurements.

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Calculation of Sensitivity of Digital Fiber-Optic Communications Receiver  
With SAGM-APD Detector

40080100b Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 16  
No 6, Nov 88 pp 117-119

[Article by Shen Wenjiang [3088 2429 3068] (Shanghai Institute of Railway  
Technology) (manuscript received May 87, revised Aug 87)]

[Text] Abstract: This article presents a method of calculating the sensitivity of a digital fiber-optic communications receiver with an SAGM-APD [separate absorption, grading, and multiplication/avalanche photodiode] detector. Specifically, the relationships between receiver sensitivity and bit rate in the high-rate region ( $>10^8$  b/s) and between the optimum gain factor and bit rate are derived.

## I. Introduction

The InP/InGaAsP/InGaAs SAGM-APD differs from the conventional Si and Ge APD both in structure and in basic principle: 1) The cavity ionization rate in the InP gain region is greater than the electron ionization rate; hence the cavity is used to produce avalanche multiplication. 2) One side of the SAGM-APD depletion layer has a three-layer structure where the electric field distribution is different from that of the conventional Si Ge APD; this would affect the calculation of the gain factor  $M_0$  and the residual noise coefficient  $F(M_0)$ . 3) The ionization rate is a function of the field strength, and therefore a function of points in space. 4) The accumulation of cavities at the heterojunction interface affects the frequency response of the SAGM-APD. 5) In determining the relationship between sensitivity and bit rate in the high frequency region, the effect of avalanche buildup time must be considered.[5]

## II. Calculation of Gain Factor and Residual Noise Factor

The structure of an APD as shown in Figure 1 is used in determining the relationships between the gain factor  $M_0$ , the residual noise factor  $F(M_0)$  and the structural parameters of the SAGM-APD.

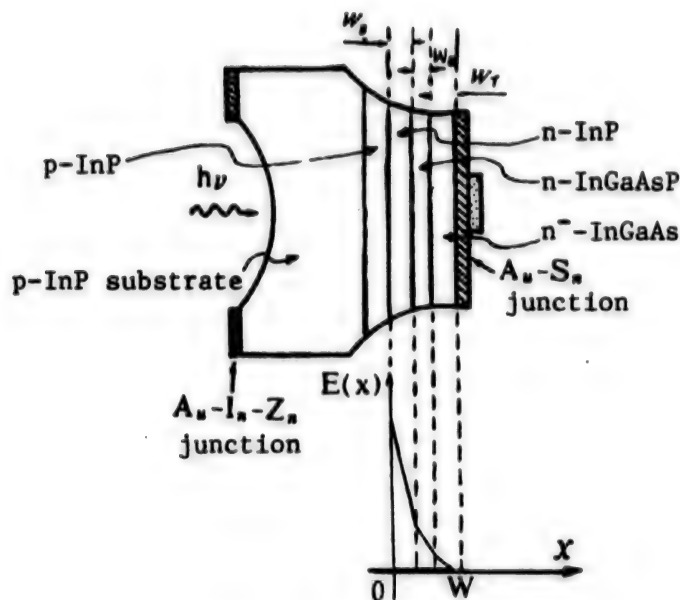


Figure 1. Structure of SAGM-APD and Electric Field Distribution in the Depletion Layer

Specifically, the gain factor at location  $x$  in the depletion layer is

$$M_0(x) = \frac{\exp\left\{-\int_0^x (a - \beta) dx\right\}}{1 - \int_0^W a \exp\left\{-\int_0^x (a - \beta) dx'\right\} dx}$$

$$= \begin{cases} \frac{1}{\rho} \exp\left\{-\int_0^x (a_s - \beta_s) dx\right\} \triangleq M_s(x) & (0 \leq x \leq W_s) \\ \frac{\xi_1}{\rho} \exp\left\{-\int_{W_s}^x (a_0 - \beta_0) dx\right\} \triangleq M_0(x) & (W_s \leq x \leq W_s + W_0) \\ \frac{\xi_1 \xi_2}{\rho} \exp\left\{-\int_{W_s+W_0}^x (a_r - \beta_r) dx\right\} \triangleq M_r(x) & (W_s + W_0 \leq x \leq W) \end{cases} \quad (1)$$

where

$$P = 1 - \int_0^{W_s} a_s \exp\left\{-\int_0^x (a_s - \beta_s) dx'\right\} dx - \xi_1 \int_{W_s}^{W_s+W_0} a_0 \exp\left\{-\int_{W_s}^x (a_0 - \beta_0) dx'\right\} dx - \xi_1 \xi_2 \int_{W_s+W_0}^W a_r \exp\left\{-\int_{W_s+W_0}^x (a_r - \beta_r) dx'\right\} dx \quad (2)$$

$$\xi_1 = \exp\left\{-\int_0^{W_s} (a_s - \beta_s) dx\right\} \quad (3)$$

$$\xi_2 = \exp\left\{-\int_{W_s}^{W_s+W_0} (a_0 - \beta_0) dx\right\} \quad (4)$$



In the above equations,  $\alpha_B$ ,  $\beta_B$ ,  $W_B$ ;  $\alpha_Q$ ,  $\beta_Q$ ,  $W_Q$ ; and  $\alpha_T$ ,  $\beta_T$ ,  $W_T$  are respectively the electron and cavity ionization rates and the width of the InP, the InGaAsP and the InGaAs layers.  $W$  is the total width of the depletion layer; in general,  $W < W_B + W_Q + W_T$ . When light illuminates the diode surface, the electron cavity pairs in the InGaAsP layer and the GaAs layer are generated at the respective rates  $G_0(x)$  and  $G_T(x)$ . Then, the initial photoelectric current density  $J_0$  is

$$J_0 = q \int_0^{W_B + W_Q + W_T} G(x) dx = q \int_{W_B}^{W_B + W_Q} G_0(x) dx + q \int_{W_B + W_Q}^{W_B + W_Q + W_T} G_T(x) dx \quad (5)$$

For the case under consideration,  $W < W_B + W_Q + W_T$ , the injected electron current density  $J_n(0)$  should be zero, and  $J_p(W)$  should be  $q \int_W^{W_B + W_Q + W_T} G_T(x) dx$ .

$M_0$  can be expressed as:

$$M_0 = \frac{q}{J_0} \left\{ \frac{J_p(W)}{q} M_T(W) + \int_{W_B}^{W_B + W_Q} G_0(x) \cdot M_0(x) dx + \int_{W_B + W_Q}^W M_T(x) \cdot G_T(x) dx \right\} \quad (6)$$

On the other hand, the residual noise factor of the cavity injection gain is: [1]

$$F(M_0) = [M_0/K_c - (2 - 1/M_0)(1 - K_c)/K_c] \quad (7)$$

where  $K_c$  is the ratio between the cavity effective ionization rate  $(\beta_B)_{\text{eff}}$  and the electron effective ionization rate  $(\alpha_B)_{\text{eff}}$  in the gain region.

$$(\alpha_B)_{\text{eff}} = \frac{1}{E(0) - E(W_B)} \int_{E(W_B)}^{E(0)} \alpha_B dE \quad (8)$$

$$(\beta_B)_{\text{eff}} = \frac{1}{E(0) - E(W_B)} \int_{E(W_B)}^{E(0)} \beta_B dE \quad (9)$$

Therefore, equations (1)-(6) can be used to calculate the gain factor  $M_0$  and equations (7)-(9) can be used to calculate  $F(M_0)$ .

### III. Calculation of Receiver Sensitivity

The calculation of sensitivity of a receiver using a SAGM-APD as detector is based on the simplified model of Ref. [3]. From this model, S. D. Personick derived an expression for the signal-to-noise ratio of a conventional avalanche diode receiver by considering only the d.c. gain factor  $M_0$ . In this article, the gain factor is taken as the average value of the three-layer structure; it is also a function of frequency: [2]

$$\frac{M(\omega)}{M_0} = \frac{\sin(\omega W/2v)}{(\omega W/2v)} \cdot \frac{1}{\sqrt{1 + (\omega RC)^2}} \cdot \frac{1}{\sqrt{1 + (\omega/e_h)^2}} \cdot \frac{1}{\sqrt{1 + (\omega\tau_a)^2}} \quad (10)$$

where  $v$  is the saturation transport velocity of the carrier,  $R$  and  $C$  are respectively the serial resistance and capacitance,  $\tau_a$  is the avalanche buildup time, and  $e_h$  is the recovery rate of cavities trapped at the heterojunction interface. For simplicity, we consider only the region where the gain factor has a weak dependence on frequency; thus, in deriving the noise term,  $M(\omega)$  is replaced by  $M_0$ . The output signal and the noise prior to the decision point are:

$$I_{11} = M(\omega) (q\eta/h\nu) P_{opt} \quad (11)$$

$$\langle i_1^2 \rangle = 2q(q\eta/h\nu) \langle M_0^2 \rangle P_{opt} \cdot B \cdot I_1 \quad (12)$$

$$\langle i_1^2 \rangle_{wc} = 2q(q\eta/h\nu) \langle M_0^2 \rangle P_{opt} \cdot B \cdot (\Sigma_1 - I_1) \quad (13)$$

$$\langle i^2 \rangle_{sc} = 2qI_d \langle M_0^2 \rangle \cdot B \cdot I_2 \quad (14)$$

$$\langle i^2 \rangle_{\text{parallel}} = \frac{d\langle i_1^2 \rangle}{df} \cdot B \cdot I_1 \quad (15)$$

$$\langle i^2 \rangle_{\text{series}} = \frac{d\langle e_1^2 \rangle}{df} \left[ \frac{BI_1}{R_L^2} + (2\pi C_T)^2 B^3 I_1 \right] \quad (16)$$

where  $B$  is the bit rate,  $P_{opt}$  is the incident optical power,  $\eta$  is the quantum efficiency,  $I_d$  is the dark current,  $h\nu$  is the incident photon energy, and  $I_1, I_2, I_3, \Sigma_1$  are waveform coefficients.[3] Also,  $\langle M_0^2 \rangle = M_0^2 F(M_0)$ , where  $M_0$  and  $F(M_0)$  can be determined from equations (6) and (7). In practice, the interference effects between bits are neglected; the input light signal is assumed to have a Gaussian waveform with probability of "0" or "1," and the output signal after equalization is assumed to have an "ascending cosine" shape in the frequency domain. With a bit error rate of  $10^{-9}$ , the sensitivity is

$$\bar{P} = \left( \frac{h\nu}{\eta q} \right) \cdot Q \cdot \left[ \frac{\langle i^2 \rangle_c^{1/2}}{M_0 \psi} + \frac{Q \cdot q \cdot F(M_0) \cdot B \cdot I_1}{\psi^2} \right] \quad (17)$$

$$\langle i^2 \rangle_c = \left( \frac{4k_B T}{R_L} I_1 \cdot B + 4k_B T \Gamma \cdot \frac{(2\pi C_T)^2}{g_n} I_1 \cdot B^3 + 2qI_d B I_1 M_0^2 F(M_0) \right) \quad (18)$$

$$\psi = \frac{\sin(\pi BW/v)}{(\pi BW/v)} \cdot \frac{1}{\sqrt{1 + (2\pi BRC)^2}} \cdot \frac{1}{\sqrt{1 + (2\pi B/e_h)^2}} \cdot \frac{1}{\sqrt{1 + (2\pi B\tau_a)^2}} \quad (19)$$

Figure 2 shows three sensitivity-vs-bit-rate curves; ((1) corresponds to the condition where the amplifier input impedance is  $10^6 \Omega$ ,  $1/e_h = 15$  ps,  $\tau_m = 4.2$  ps; (2) corresponds to the condition where the amplifier input impedance is  $10^6 \Omega$ ,  $1/e_h = 15$  ps,  $\tau_m = 11.5$  ps; (3) corresponds to the condition where the amplifier input impedance is  $10^4 \Omega$ ,  $1/e_h = 15$  ps,  $\tau_m = 4.2$  ps; (4) corresponds to the ideal condition where the amplifier input impedance is  $10^6 \Omega$ ,  $1/e_h = 0$ , and  $\tau_m = 0$ ). It can be seen from the figure that in the

low-bit-rate region ( $<400$  Mb/s), the input impedance of the amplifier (including the load resistance of the SAGM-APD) can improve the receiver sensitivity. In the high-bit-rate region ( $>400$  Mb/s), the avalanche buildup time has a significant effect on sensitivity. This illustrates the importance of input impedance in improving avalanche buildup time. Figure 3 shows the relationships between the optimum gain factor  $(M_0)_{\text{opt}}$ ,  $\psi$ , and the bit rate. The  $(M_0)_{\text{opt}}$ -vs- $B$  curve is based on the condition of high impedance and  $\tau_m = \tau_0/M_0 = 4.2$  ps; it is seen to vary in the range 6-16. Therefore, it is not necessary to strive for a high  $M_0$  value in designing receivers with SAGM-APD as the front end. The  $\psi$ -vs- $B$  curve indicates that for bit rates less than 1 Gb/s,  $\psi$  only varies by 10 percent; this result supports the feasibility of using the d.c. gain factor  $M_0$  in deriving the noise expressions (12)-(14).

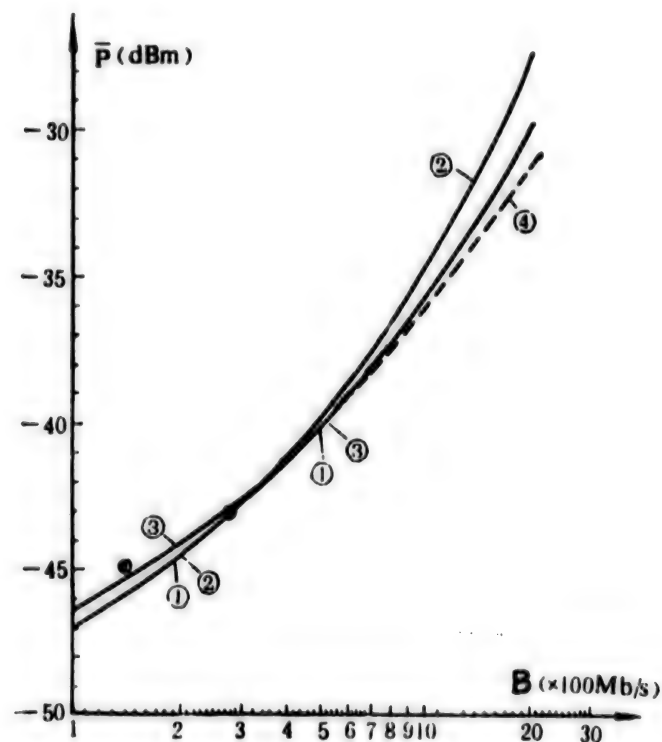


Figure 2. Relationship Between Sensitivity  $\bar{P}$  and Bit Rate  $B$  (bit error rate =  $10^{-9}$ ,  $\lambda = 1.55 \mu\text{m}$ )

The two circles indicated in Figure 2 are data obtained from an experiment conducted by the Japanese International Telecommunications and Telephone Society (KDD) in 1986 using a 160-km underwater relay system with  $\lambda = 1.55 \mu\text{m}$ . [4]

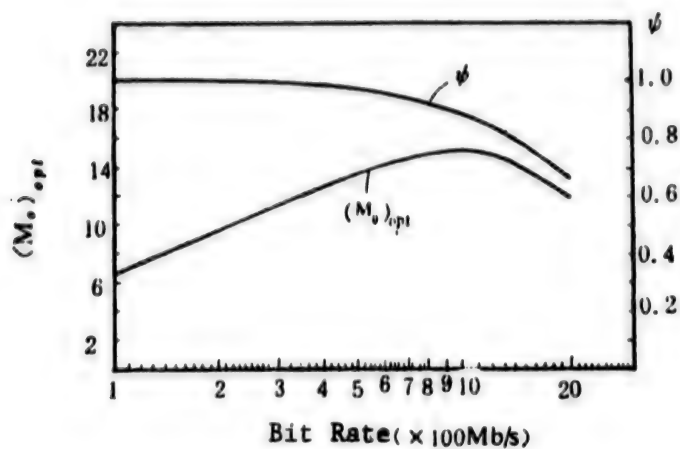


Figure 3. Relationship Between Optimum Gain Factor  $(M_o)_{opt}$  and  $\psi$  of SAGM-APD and Bit Rate

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Military Telephone Exchange Completed

40080146a Shanghai DIANXIN KUAIBAO [TELECOMMUNICATIONS INFORMATION]  
in Chinese No 2, Feb 89 p 11

[Summary] The Beijing military [stored] program-controlled (SPC) telephone exchange network became formally operational on 6 December 1988. This large-scale SPC network meets international standards for the eighties and consists of an SPC system and a fiber-optic cable transmission system using pulse code modulation. Installed capacity will be three times that of the old network, and there are five times as many [information] channels for hook-up to public networks.

Fiber-Optic Line for Hainan Province

40080152a Beijing ZHONGGUO DIANZI BAO in Chinese 21 Feb 89 p 2

[Summary] Authorities in Hainan Province plan to install a long-distance fiber-optic communications line in the eastern part of the island. Surveying and design will be carried out by the Ministry of Posts & Telecommunications' Beijing Design Institute and Wuhan Institute of Posts & Telecommunications Science. The feasibility study for this project has been completed, and the initial design and early construction are currently underway. The planned investment for this 960-circuit line is 40 million yuan, and initial operation is scheduled for the end of 1990.



## Fiber-Optic-Sensing Electric-Field Tester

40080152b Beijing DIANZI SHICHANG [ELECTRONICS MARKET] in Chinese 2 Mar 89 p 1

[Summary] Integrating optical technology, fiber-optic sensor technology, and signal-processing technology, Institute 26 of the Ministry of Machine-Building & Electronics Industry has developed the GDC-1A fiber-optic-sensing electric-field tester, which recently passed its technical certification in Chongqing. The main technical indicators for this product--which represents the first domestic application of fiber-optic sensor technology to electric-field detection--match those of a similar product first marketed by Mitsubishi Electric Corporation in 1985. The GDC-1A consists of an electric-field signal sensing system and an optoelectronic signal detection system. Applications include measuring the discharge from electrical machines, the ion-flow distribution near ultrahigh-voltage transmission lines, and the characteristics of wide-gap glow discharge [tubes]. This instrument has been employed by the Ministry of Energy Resources' Wuhan High-Voltage Research Institute and the Eastern Electric Machine Plant at sites such as Longyang Xia [in Qinghai Province].

New-Generation Digital Fiber-Optic System

40080152c Beijing ZHONGGUO DIANZI BAO in Chinese 14 Mar 89 p 1

[Summary] A new-generation 34Mb/s [DS3] digital fiber-optic communications system--consisting of a 34Mb/s optical terminal, optical repeater, and multiplexing equipment; a 2-8-34Mb/s [DS1/DS2/DS3] optical terminal, optical repeater, and multiplexing equipment; and 2-8-34Mb/s drop-insert multiplexing equipment--recently passed accreditation at the Ministry of Posts & Telecommunications' Meishan Communications Equipment Plant. This system, which meets CCITT standards, uses single-mode optical fiber of the 4B1H code type, and can carry 480+60 circuits, or 540 effective voice circuits. The system includes a computer monitoring and control subsystem and can be linked up with digital microwave transmission systems, satellite transmission systems, and [stored] program-controlled [telephone] exchanges to form a high-capacity long-distance digital communications system.

New Fiber-Optic Products

40080152d Beijing ZHONGGUO DIANZI BAO in Chinese 14 Mar 89 p 3

[Summary] Anhui Province's Huainan [3232 0589] Fiber-Optic Communications Company has developed three new products: a 1.3-micron long-wavelength multi-mode graded-index fiber-optic preform, a high-speed pulling machine for multi-mode graded-index optical fiber, and a nylon-coated tight-pack optical fiber. The preform, made with the MCVD [modified chemical vapor deposition] technique, is pulled to manufacture a fiber with the following specifications: average 1.3-micron fiber-optic transmission loss is less than 0.74dB/km, minimum loss is 0.49dB/km, and maximum bandwidth is 3509MHz·km; these indicators meet international standards. The nylon-coated tight-pack fiber is used in public communications networks and in fiber-optic sensors.

## Beijing Electron-Positron Collider

### High Energy Physics Developments

40080031 Beijing WULI [PHYSICS] in Chinese Vol 17 No 8, Aug 88 pp 456-461

[Article by Huang Tao [7806 3447] of High Energy Physics Institute, Chinese Academy of Sciences: "A Look of the Beijing Electron-Positron Collider From the Development of High Energy Physics"]

[Text] Abstract: The Beijing electron-positron collider is the first high energy physics experimental base in China. Its energy band is suitable for detailed research on charmed particles. This paper points out the potential research applications of the Beijing electron-positron collider based on the trend of development in high energy physics in the world. To become an influential institution, the Beijing electron-positron collider must meet three conditions: high accelerator luminance, high detector efficiency and high data processing capability. In addition, the paper also discusses the use of the Beijing electron-positron collider as a synchrotron radiation device.

#### I. Engineering Aspect of the Beijing Electron-Positron Collider

An electron-positron collider is an important device in high energy physics research. The Beijing electron-positron collider is the first experimental facility in high energy physics in China. It is also a major project in the modernization of science and technology in China.

Since laying its foundation on 7 October 1984, the building construction work was completed in 3 years. The installation of the accelerator began in 1986. The positron generating part of the linear accelerator was successfully tested. The storage ring was about to be installed. The machining of the magnets of the drift chamber of the detector, shower counter and flight time detector was completed and they were expected to be finished by the end of 1987. The Beijing spectrometer will be installed and tested in the second half of 1988. In summary, all major components of this project are proceeding smoothly according to schedule. Electron-positron collision is expected to occur by the end of 1988 to be used in high energy physics experiments.

This national focal point project occupies more than 100 mu of land. It consists of five major components: 1) electron-positron linear accelerator, which generates accelerated electrons and positrons and is the injector for the storage ring; 2) storage ring, which stores electrons and positrons in the ring to be further accelerated for collision; 3) detector (Beijing spectrometer), which is used to identify the particles and determine the charge, momentum, energy, track and spin of every particle for high energy physics research; 4) synchrotron radiation zone, where cyclotron radiation is used to generate synchrotron radiation for a variety of experiments; 5) computer center, where the vast amount of data is processed. The Beijing electron-positron collider is schematically shown in Figure 1.

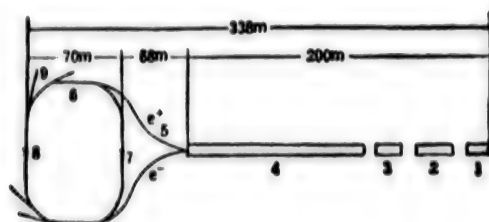


Figure 1. Schematic Diagram of the Beijing Electron-Positron Collider

1--30 MeV pre-injector; 2--120 MeV linear accelerator; 3--positron target; 4--electron-positron linear accelerator; 5--beam transport system; 6--storage ring; 7, 8--detector; 9--synchrotron radiation zone.

## II. High Energy Physics--Cutting Edge in the Exploration of the Microscopic World

High energy physics is also called particle physics. It is on the cutting edge of science in the exploration of the microscopic world. The exploration of the microscopic world includes two aspects: structures of matters and laws of motion.

Before 1960, people believed that everything in this universe is composed of elementary particles such as electrons, protons, neutrons, etc. In the early 1960's, more than 100 elementary particles had been discovered. However, a series of experiments revealed that these elementary particles are not elementary. Instead, they have certain internal structures. They are composed of more elementary particles called stratoms. Hence, the term "elementary particles" is no longer in use and it is called particles.

These particles are divided into three types according to their characteristics: 1) hadron, 2) lepton and 3) boson. Hadrons are particles which interact strongly with one another, such as proton, neutron, hyperon, meson,  $\pi$  meson, K meson and  $J/\psi$  particle. The majority of the particles belongs to this type. This type of particles has been experimentally shown to have an internal structure. They are composed by stratoms or stratoms and anti-stratoms. Leptons interact weakly with one another or with electromagnetic field and do

not participate in strong interaction. No internal structure has been revealed experimentally to date. They include electron, electronic neutrino,  $\mu$  particle,  $\mu$  neutrino,  $\tau$  particle,  $\tau$  neutrino and their anti-particles. Bosons are coupling mutual interactions. For instance, electromagnetic interaction is transmitted by photons. Four years ago, W and Z particles were found to be bosons responsible for weak interaction. Gluons are responsible for transmitting strong interaction.

Thus, stratoms (u, d, s, c, b and their anti-particles), leptons (e,  $\nu_e$ ,  $\mu$ ,  $\nu_\mu$ ,  $\tau$ ,  $\nu_\tau$  and their anti-particles) and bosons ( $\gamma$ ,  $W^\pm$ ,  $Z^0$  and gluon) are particles of the same level. They are the smallest elements in matters (as we presently understand it). Within the energy range of existing accelerators, there is no direct evidence of any internal structure. Theoretically, they are treated approximately as point particles. This is just as we treat a nucleus as a point particle in atomic physics. It is experimentally shown that each stratom has three colors. Therefore, there should be 30 stratoms and anti-stratoms, 12 septons and 12 bosons including 8 gluons. These are the objects to explore in the microscopic world. In addition, theory predicts the existence of particles such as top quark, magnetic monopole, Higgs particle, axion and super symmetry adjointon. High energy physics is to study the characteristics these small elements and the laws governing the interaction to combine and convert from one another.

### III. Discovery and Status of Research of Charmed Particles

Samuel Ding and Likete (?) independently discovered the  $J/\psi$  particle in November 1974. The mass of this particle is heavy (3.1 GeV), which is much heavier than an ordinary hadron. Moreover, the width is much narrower than that of an ordinary hadron. In order to investigate the  $J/\psi$  family of particles which were difficult to explain with existing theories, new concepts and theories have been developed in the past decade. New experimental techniques have also been developed. High energy physicists called it the November revolution.

As we mentioned before, a hadron is composed of stratoms. Before 1974 we knew that there are three types of quarks: u (up), d (down) and s (singular). They form over a hundred hadrons. A  $J/\psi$  particle cannot be formed by the u, d and s quarks. Therefore, people introduced a new quark c, called charm. The  $J/\psi$  particles are formed by c quark and its anti-particle. Ten days after the discovery of the  $J/\psi$  particle, its first radial excited state  $\psi'$  was discovered. Over the past decade, more than 20 members of the family such as  $J/\psi$ ,  $\eta_c$ ,  $\psi'$ ,  $\psi''$ ,  $\psi'''$ ,  $\psi''''$ ,  $\chi^0$ ,  $\chi^1$ ,  $\chi^2$ ,  $D^\pm$ ,  $D^0$ ,  $\bar{D}^0$ ,  $F^\pm$ ,  $D^*$ ,  $D^{**}$ , etc., have been found. This abundant spectrum has been studied with precision. This proves the existence of the c quark. The c quark is also heavy. The velocity in a series of bound motion in the  $\psi$  family is also low. It can be described by a non-relativistic quark potential model. The energy spectrum and properties obtained from the Schrodinger equation can explain the present experimental data well. This allows us to further understand the properties and structure of quark (see Figure 2).



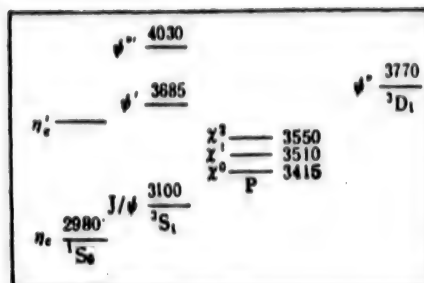


Figure 2. The J/ψ Family Energy Spectrum

The Stanford Linear Accelerator Center (SLAC) in the United States has conducted detailed studies on the properties of charm. For example, the electromagnetic radiation decay processes of various radial and orbital excited states of J/ψ and the decay of their strong interaction have been investigated. In the past couple years, the decay of the weak interaction between D and F particles was measured. The properties of the F particle were measured in detail in 1986. By the end of 1986, they gathered approximately 3,000,000 J/ψ incidents and determined its various decay channels. They also collected close to 40,000 D meson incidents and analyzed various decay channels. In 1986, they accumulated F meson incidents and obtained some preliminary results. Based on the incidents gathered, they conducted a great deal of data analysis. SLAC used a part of the IBM3081-K time for data processing. The amount of computing time spent is equivalent to having five Vax 11/780's operating all year round.

SLAC presently uses Mark III as the detector in charm research. Although the work has been going on for 6 years, however, there are still many physical problems to be resolved.

### 1. Determination and Study of Gluons

Quantum chromodynamics tells us that the interaction between quarks is very strong. This interaction takes place through gluons. Two or three gluons may form a bound state, which is a gluon cluster. The electromagnetic decay process of the J/ψ particle is the best laboratory for the investigation of gluons. The  $\psi'$  particle was discovered on the Mark III in 1980. People believed that it might be a gluon cluster. However, it cannot be separated from the E particle. This is the so-called  $\psi'/E$  mystery. We need more incidents to explain the complicated structure in this energy region. In addition to the  $\psi'$  particle,  $\theta$  particle,  $g_T$ ,  $g_T'$  and  $g_T''$  may be gluon clusters.  $g_T$ ,  $g_T'$  and  $g_T''$  are observed in hadron reactions. They have not yet been seen in  $e^+e^-$  collision experiments. In conclusion, although radiation decay of J/ψ is an ideal laboratory for the study of gluon cluster, however, it is very difficult to confirm that the particle is a gluon cluster. There are two reasons. One is that we do not know the mass spectrum of the gluon cluster. Regardless of using the lattice gage theory or the pocket model, it is only possible to estimate that the mass is in the 1-3 GeV range. It is experimentally difficult to accurately adjust the mass spectrometer to locate gluon clusters. Second, the structure near 2 GeV is very complex. For example,

more than 26 bound quark and anti-quark states may exist. Only a few states discovered to date can fill in the quark model. There are still many particles not discovered yet. Their mass range coincides with that of the gluon clusters. The state experimentally measured might be a hybrid state. In addition, there are bound states formed by quarks, anti-quarks and gluons. The state of four quarks, a pair of quarks and a pair of anti-quarks, is also in this energy region. It is all mixed together and difficult to separate. More  $J/\psi$  incidents are required to get more accurate results.

## 2. Study of $\xi$ Particle Properties

The  $\xi$  particle was discovered on the Mark III in 1983. However, the DM2 group in France did not see it. In order to ascertain presence and to measure the characteristics of the  $\xi$  particle, more incidents are required. In order to determine its spin and parity, it needs approximately 10,000,000 incidents.

## 3. Study of the Decay Channel and Mechanism of the D Meson

The mass of a D meson, formed by a charm and a light quark, is 1870 MeV. Only  $\psi''$  can decay to a pair of D mesons. D meson primarily decays to its final product via weak interaction. The charm quark  $c$  decays to a singular quark  $s$  or down quark  $d$ . The other light quark  $u$  or  $d$  remains unchanged (see Figure 3).

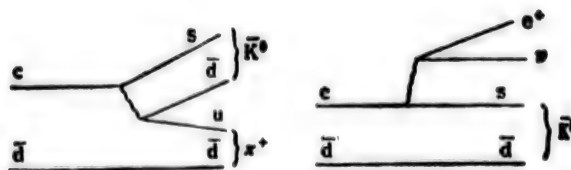


Figure 3.  $D^+$  meson decaying to  $\bar{K}^0 \pi^+$  or  $D^+$  decaying to  $\bar{K}^0 e^+ \nu$ .  $D^+$  is composed of  $(c\bar{d})$ , i.e., one charm  $c$  and one anti-quark  $\bar{d}$ ;  $W$  is the boson which couples weak interaction.

Experimental fact tells us that the probability for  $c$  quark to decay to  $s$  quark is much higher than that to  $d$  quark, which is usually expressed by the Cabbibo angle  $\theta$ . Based on an intuitive observer model, the decay width  $\Gamma$  can be expressed as,

$$\begin{aligned}\Gamma(c \rightarrow s\bar{d}) &\propto 3 \cos^4 \theta, \\ \Gamma(c \rightarrow d\bar{u}) &\propto 3 \cos^2 \theta \sin^2 \theta, \\ \Gamma(c \rightarrow s\bar{u}) &\propto 3 \cos^2 \theta \sin^2 \theta, \\ \Gamma(c \rightarrow d\bar{s}) &\propto 3 \sin^4 \theta, \\ \Gamma(c \rightarrow s l^+ \nu_l) &\propto \cos^2 \theta, \\ \Gamma(c \rightarrow d l^+ \nu_l) &\propto \sin^2 \theta,\end{aligned}$$

The two latter decay products include leptons and are called lepton decay. The first four reactions do not include any lepton and are called non-lepton decay. Roughly speaking, 60 percent of the final state of D meson decay is non-lepton decay process and 40 percent is lepton decay process. Since Cabbibo  $\theta$  is approximately

$$\left(\frac{\sin\theta}{\cos\theta}\right)^2 \approx \frac{1}{20},$$

$c \rightarrow s$  is a Cabbibo favored process and  $c \rightarrow d$  is a Cabbibo suppressed process. For instance, the first reaction is a Cabbibo favored process. The second and third reactions are primary suppressed processes. The fourth is a secondary suppressed process. The fifth is a Cabbibo favored process and the sixth is a Cabbibo suppressed process. Roughly speaking, the probability of a Cabbibo primary suppressed reaction is 1/20 of that of the favored process. The probability of a secondary suppressed process is even less, approximately 1/400 of that of the favored process. If 40,000 D incidents are measured by the detector, there are only 100 secondary suppressed Cabbibo processes and only 60 non-lepton decay processes. Because there are many non-lepton decay channels, each channel almost cannot detect any incident. It is even more difficult to talk about accuracy. The Mark III detector in the United States has detected 37,400  $D\bar{D}$  incidents. The measurement of the Cabbibo favored process has been perfected. The problem is to gather more incidents to raise accuracy. As for the primary suppressed Cabbibo process, only a dozen or dozens of incidents have been gathered in each channel, which only provide some rough values. Mark III has not yet observed any secondary suppressed Cabbibo process. In D meson decay, its life time is always a mystery. Based on the intuitive quark model, the life of the  $D^+$  meson is equal to that of the  $D^0$  meson. However, experimental results showed that the former is 2.3 times larger than that of the latter. Thus, a question is raised. What mechanism increases the decay width of  $D^0$  meson and decreases the decay width of  $D^+$  in D meson decay. Accurate measurements will provide basis to judge the mechanisms proposed to date. Other subjects to be further studied include the determination of the D meson generation cross-section and decay channels, as well as the  $D^0-\bar{D}^0$  combination and CP destruction.

In 1986, based on the success in the  $J/\psi$  and  $\psi''$  energy regions, Mark III could operate in the higher energy level of 4.14 GeV. The purpose is to determine the properties and decay channels of the F and  $F^*$  meson with preliminary results.

#### IV. Objectives of the Beijing Electron-Positron Collider

When the Beijing spectrometer began to operate, the Mark III at Stanford had been in service for 7 years. On one hand, this is a giant step forward in filling the blank of a high energy physics base. On the other hand, it is difficult for the Beijing spectrometer to accomplish major achievements 7 years after Mark III began to operate. In the status report of charmed particle research discussed earlier, we know that the degree of difficulty of the physical problems left behind by the Mark III spectrometer is very high. This requires that both the accelerator and the spectrometer of the Beijing electron-positron collider projector have excellent characteristics.

First, we hope to gather more incidents in order to obtain more accurate physical results statistically. This requires that the luminance of the collider should be high, the energy dispersion be low and the operation be smooth. Luminance  $L$  is an important indicator of the performance characteristics of the collider. The number of particles generated after the electron-positron collision is proportional to  $L$ . The number of incidents =  $L\sigma T$ , where  $\sigma$  is the cross-section and  $T$  is time. Luminance is the number of particle collision incidents per square centimeter cross-section per second. Therefore, the higher the luminance is the more frequently particles collide and the better the performance of the collider is. Luminance is dependent upon energy. In the operating energy range, the collider has a maximum luminance corresponding to the energy of the particle. Outside this particle energy band, the luminance drops off rapidly. In general, a collider can only operate in a narrow energy band. The Beijing electron-positron collider is designed to have a peak luminance of  $1.7 \times 10^{31} \text{ cm}^{-2}\text{s}^{-1}$  when the energy of the particle beam is at 2.8 GeV. When operating at 3.1 GeV, the luminance is  $5 \times 10^{30} \text{ cm}^{-2}\text{s}^{-1}$ . This is 10 times higher than that of the Spear which also operates in this range. This means in the  $J/\psi$  energy range, the number of incidents it gathers would take Spear 10 years to collect. This advantage allows the Beijing electron-positron collider to conduct research at the state-of-the-art level.

Second, the detection efficiency and resolution of the Beijing spectrometer must be high. A high energy accelerator can only provide a particle beam. Electron and positron beams are further accelerated in the storage ring to be ready for collision. Their interaction results in a series of secondary particles. The mission of the detector is to record and analyze the type, direction, momentum and energy of these particles and to reach some conclusions. The Beijing spectrometer in the Beijing electron-positron collider is the detector. It consists of a central drift chamber, main drift chamber, time of flight counter, shower counter and  $\mu$  particle counter. Its diameter and length are approximately 6 m and 4 m, respectively, and weighs about 400 t. The Beijing spectrometer is located at the point of collision. The central drift chamber acts as the trigger. The main drift chamber on the outside is used to measure the tracks of charged particles and to determine their energy and momentum losses in order to identify electron,  $\pi$  meson, K meson and proton. Further outside is the time of flight counter which is used to determine the flight time of the particle in order to differentiate charged particles such as  $e^\pm$ ,  $\pi^\pm$ , K and p and to eliminate background cosmic ray. The shower counter is located outside the time of flight counter in order to measure the energy and direction of photon and to identify electron. Further outside is a coil which is used to generate a 4,000 G magnetic field. It is wrapped with magnets. The very outside is the  $\mu$  particle detector. Both end caps are equipped with a time of flight counter and a shower counter. The entire detector has a large detection solid angle. It can identify charged particles well. It also has excellent spatial and momentum resolution for charged particles. Its spatial and energy resolution for low energy photons are also excellent.

Third, it is important to have a firm grasp on data processing. If detectors are the eyes, then data processing is the brain. The Beijing spectrometer

records one incident per second. Assuming that the electron-positron collider operates 6,000 hours per year, the number of incidents to be processed is approximately 20,000,000. This requires a large computer with special programs to analyze the data to obtain results. The computer for data processing is divided into on-line and off-line operations. The on-line computer controls and monitors the detector, and also records, analyzes and preliminarily processes the data. The off-line computer processes millions and billions of data points on magnetic tape and presents the experimental results graphically. Therefore, the collider center must be equipped with a large computer in the computer center.

After these three necessary conditions are met, we will be able to solve the problems left behind in this energy range. These problems include:

- (1) Large statistical measurement of radiation decay of  $J/\psi$  and study of new particle states (e.g., gluon clusters,  $\xi(2.2)$  particle, quadruple quark state, Higgs particle, etc.) and accurate measurement of  $J/\psi$  decay channels.
- (2) Large statistical measurement of decay channels of D mesons, particularly primary and secondary suppressed Cabibbo decay processes (including CP destructive parameter).
- (3) Measurement of decay channels for F meson and  $\tau$  lepton.
- (4) Determination of the characteristics of charmed baryon (e.g.  $\Lambda_c$ ) and its decay branch ratio.
- (5) Analysis of charmed particle spectrum and binding potential. To date, the  $1P_1(J^{PC} = 1^{+-})$  state in the charmed particle family has not yet been discovered.
- (6) Radiation decay and strong interaction decay of  $\psi'$ , such as  $\psi' \rightarrow \pi^0 1P_1$ ,  $1P_1 \rightarrow \gamma \eta_c$ , and the spin parity of  $\eta_c$ .
- (7) Others, such as the measurement of R and verification of radiation decay processes using quantum chromodynamics.

From the engineering schedule of the electron-positron collider, it is expected that the Beijing spectrometer can be installed at the collision point in September 1988. It will then be adjusted to get ready for experimental work. The plan is to install and adjust the Beijing spectrometer from September 1988 to the end of 1988. From January to June 1989, we will conduct preliminary testing of the entire system and put it in operation. From July 1989 to the end of 1990, the spectrometer will be thoroughly tested and will be operational in the  $J/\psi$  energy range. From early 1991 to the end of 1992, we will spend 2 years to measure various decay channels of D mesons. We hope to reach an integrated luminance of  $40 \text{ Pb}^{-1}$  in the  $\psi'$  energy region. If these experiments proceed smoothly, we plan to study F meson and charmed baryon in 1993.



In addition, the Beijing electron-positron collider, which is built for high energy physics research, has an important by-product--synchrotron radiation. Synchrotron radiation has been widely used in science and technology, such as atomic and molecular physics, physics of condensed state, chemistry, life science, material science, X-ray lithography in VLSI circuit and micro-technology. As described earlier, electrons and positrons are accelerated in the storage ring to be ready for collision. Under the influence of the magnetic force, electrons are accelerated perpendicular to the trajectory and the direction of the magnetic field. Electromagnetic radiation is released. The energy of the radiation is proportional to the fourth power of the electronic energy. This type of radiation was first discovered in a synchrotron. Therefore, it is called synchrotron radiation.

Synchrotron radiation is far more superior over conventional X-ray source or vacuum ultraviolet source. It is highly collimated and has a wide usable band. It has a very large photon flux and is highly polarized. These advantages revolutionized a series of research work in science and technology. It also attracted a series of researchers to work with synchrotron radiation.

In recent years, several electron storage rings have been built to generate synchrotron radiation, instead of for high energy physics research. Electron storage ring synchrotron radiation devices have been built in the United States, West Germany, Italy, the United Kingdom, and the USSR. A synchrotron radiation laboratory will be built in Hefei. The Beijing electron-positron collider will also be used as a synchrotron radiation device in research and development, in addition to high energy physics research.

#### V. Standing of Beijing Electron-Positron Collider in High Energy Physics

Since the construction of the first accelerator in 1932, on the average the energy of the accelerator increased by 10 folds. Compared to the first accelerator, the energy has increased over 1 million times. The overall trend is to increase energy and luminance. In the development of modern accelerators, colliders are in the main stream. In the 1970's, several electron-positron colliders were constructed. In the 1980's, the random cooling technique proposed by Van der Meer in Western Europe plays a key role in the successful collision between protons and anti-protons. The SPPS, which was responsible for the discovery of  $W^\pm$  and Z boson, is a proton-anti-proton collision. The maximum beam energy is as high as 450 GeV. Tristan, which was recently constructed in Japan, is an electron-positron collider. The beam energy is 30 GeV. LEP, which is under construction in Western Europe, is also an electron-positron collider. Each beam is 50 GeV. The Beijing electron-positron collider is not in the lead. Its energy is comparable to that of similar devices built in the United States in the 1970's. However, the luminance is higher than that of similar devices. This means that our device can capture more incidents. Because there are still many unresolved physical problems in this region, the Beijing electron-positron collider can be used as an important window in high energy physics research. It is possible to make some breakthroughs in charmed particle research. Therefore, to choose the Beijing electron-positron collider as the first experimental base in high energy physics in China not only fits our needs but also lets us stay near



the cutting edge of high energy physics. It can lay a good foundation for high energy physics in China and can produce some research results of substance in the world.

#### 250 MeV Section of BEPC 1.1/1.4 GeV $e^{\pm}$ LINAC

40080038 Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 12 No 3, May 88 pp 365-371

[Article by the Electron LINAC Department, Institute of High Energy Physics, Chinese Academy of Sciences: "The 250 MeV Section of the BEPC 1.1/1.4 GeV  $e^{\pm}$  LINAC"; manuscript received 13 November 1987]

[Text] Abstract: Four beam adjustment tests were scheduled in the installation phase for the initial 250 MeV section of the BEPC 1.1/1.4 GeV  $e^{\pm}$  LINAC. In May 1987, an electron current pulse of 760 mA at 250 MeV was obtained. A 99 MeV positron current pulse at 2.5 mA was obtained by bombarding the conversion target with a 785 mA electron beam at 150 MeV. All technical specifications were tested and found to meet design requirements. It has achieved the same technical level as that of similar accelerators in the world.

The 1.1/1.4 GeV  $e^{\pm}$  LINAC<sup>2</sup> is the source accelerator for the BEPC which generates and accelerates electrons and positrons and then injects them into the storage ring of the collider. When the 250 MeV section is used for positron injection, a conversion target is bombarded with a 150 MeV electron beam to produce positrons and electrons (see Figure 2). The captured positrons are then accelerated to 100 MeV. In electron injection, it is possible to obtain a 250 MeV electron beam with 1 percent energy dispersion. There are 12 identical acceleration units following the 250 MeV section. Each unit has a high power klystron which feeds microwave power to four constant gradient accelerators through an energy doubler. Each unit contributes 120 MeV in energy.

The 250 MeV section consists of three different accelerating systems:<sup>1</sup>

The first section includes a beam pre-buncher, a  $\beta = 0.75$  beam buncher and a 3.05 m long constant gradient accelerator tube.<sup>1</sup> The pre-buncher requires a working field strength of 17.48 kV/cm. The field strength of the  $\beta = 0.75$  beam buncher is 35 kV/cm. As for the  $\beta = 1$  constant gradient accelerator tube, the field strength is 120 kV/cm. This section contribute 30 MeV to the energy of the beam with an electron capture efficiency of 81 percent. A high power klystron is used to simultaneously feed microwave energy to the pre-buncher, buncher and accelerator tube. In addition, microwave energy is transmitted through a coaxial cable from a 20 dB coupler to excite the 15 high power klystrons behind it.

The second part of the 250 MeV section is a high power klystron which feeds microwave energy to four constant gradient accelerator tubes through an energy doubler.<sup>1</sup> The design requirement for this section is to contribute 120 MeV to the beam. There are 12 such units in the 250 MeV sections and the energy can be calculated as follows:



$$E = 1.51 \times 20.83 \sqrt{P(\text{MW})},$$

where  $P$  is the pulse power of the klystron. By taking wave guide loss into account, approximately 10 percent of the energy is lost. Some 120 MeV has been obtained in this unit. The power output of the klystron is approximately:

$$P = \left( \frac{E}{1.51 \times 20.83} \right)^2 \frac{1}{0.9} = 16.17 \text{ MW}.$$

The maximum power level of the klystron has not been achieved yet. Therefore, the goal of 1.4 GeV for the whole system can be achieved.

The third part of the 250 MeV section is the positron source, including a positron producing target, positron capturing system, and focusing and accelerating system. The positron accelerating system has three constant gradient accelerating tubes. The microwave power for the first one,  $A_5$ , is supplied by a high power klystron. The other two ( $A_6$  and  $A_{55}$ ) are energized by another klystron. The positron converter consists of a positron target (a tungsten target which is 10 mm in diameter and 6 mm thick) and a 6 kA focusing solenoid. The latter captures the widely scattered positrons from the target.  $A_5$ ,  $A_6$  and  $A_{55}$  are equipped with dc focusing coils which can generate a longitudinal magnetic field of approximately 3 kG to simultaneously accelerate and focus positrons. The positron energy level reaches 100 MeV at the end of the three accelerating tubes.

Table 1. Beam Characteristics in the 250 MeV Section

	Design value	Test result
Electron gun emission current $I_{\text{Gun}}$ (mA)	1000	920
Target bombarding beam $I_{e^-}$ (mA)	500	785
Target bombarding electron beam energy $E_{e^-}$ (MeV)	150	148
Target bombarding electron beam cross-section $\phi$ (mm)	2-3	<2.5
Positron energy $E_{e^+}$ (MeV)	80-100	99
Positron current intensity $I_{e^+}$ (mA)	1.5	2.5
Positron capture rate $e^+/e^- \cdot \text{GeV}$	0.020	0.0215
Electron beam energy $E_{e^-}$ (MeV)	250	250
Electron beam intensity $I_{e^-}$ (mA)	500	760

Major test results of the 250 MeV section are listed in Table 1. Figures 4 and 5 show the energy dispersion diagrams in the 30 MeV and 150 MeV sections, respectively. In order to measure the beam energy and energy dispersion, a piece of AF995R  $\text{Al}_2\text{O}_3$  fluorescent plate was placed on the focal plane behind the deflection magnet. A camera system converts the optical signal into electrical signal to be processed by the computer.\* The accuracy of energy dispersion measurement is 0.1 percent. The energy dispersion in the 30 MeV

\*The beam measuring system was developed by the linear electron beam measuring group in the automatic control laboratory of our institute.

section has a key effect on the final characteristics of the beam. One factor is the microwave phase modulation resulting from the voltage fluctuation in the klystron and the traveling wave tube. The microwave power is supplied by 3  $\mu$ s pulses in that section. The accelerating tube is filled at 0.84  $\mu$ s. The electron beam pulse width is 2.5 ns. The energy dispersion effect is the phase change of voltage fluctuation in  $(0.84 + 0.0025)$   $\mu$ s. The voltage wave form of the  $K_1$  klystron is shown in Figure 6 [not reproduced] and the measured microwave phase modulation is approximately  $5^\circ$ . Since the pulse width of the electron beam is very narrow, the effect of phase modulation on energy dispersion is significantly reduced.

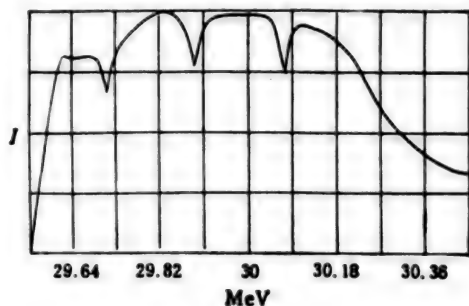


Figure 4. Beam Energy Dispersion at 30 MeV

Full width half maximum in x-direction,  $\text{FWHM}(x)$ , 19.7 mm; energy dispersion measured by AM1 is  $\pm 1.2$  percent.

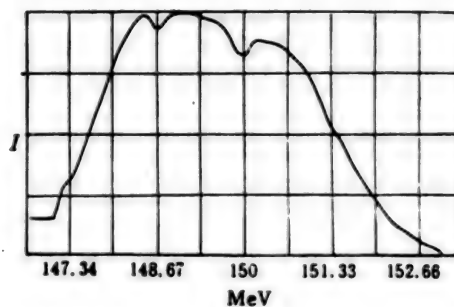


Figure 5. Beam Energy Dispersion at 150 MeV

Full width half maximum in x-direction,  $\text{FWHM}(x)$ , 13.9 mm; energy dispersion measured by AM2 is  $\pm 1.2$  percent.

The cross-section of the bombarding electron beam has an important impact on the quantity of positrons generated. Figure 7 shows the cross-section of the electron beam.

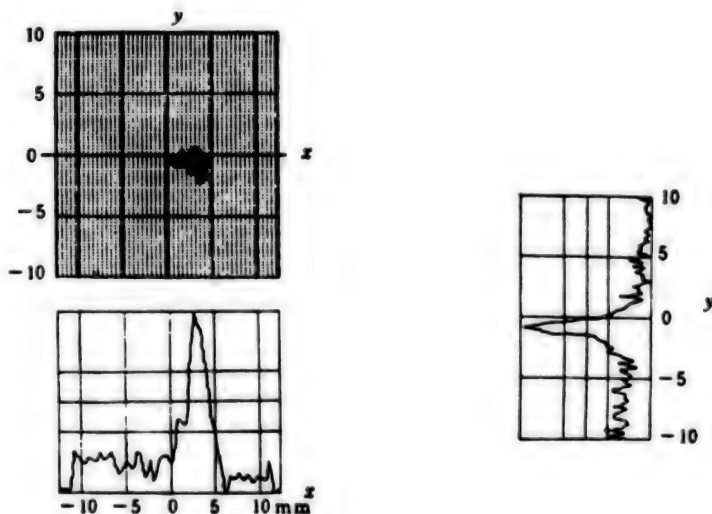


Figure 7. Bombarding Electron Beam Cross-Section  
 $\text{FWHM}(x)$ : 2.5 mm;  $\text{FWHM}(y)$ : 1.5 mm

Table 2 lists the contribution of each portion of the 250 MeV section to the energy of the beam.

Table 2. Energy Contribution of Various Accelerating Sections

<u>Klystron</u>	<u>Accelerating tube</u>	<u>Beam energy (MeV)</u>
K <sub>1</sub>	A <sub>0</sub>	30
K <sub>2</sub>	A <sub>1</sub> -A <sub>4</sub>	120
K <sub>3</sub> , K <sub>4</sub>	A <sub>5</sub> , A <sub>6</sub> , A <sub>55</sub>	99

A beam transformer is used to measure the intensity of the beam.<sup>1</sup> The range is 0.2 mA-2A. The rise time is <1 ns. The relative error is 5 percent. The measured beam capture index (ratio of the beam current at 150 MeV to electron gun injection current) is:

$$785 \text{ mA} / 920 \text{ mA} = 0.85$$

The beam transport efficiency (ratio of current at the outlet of 250 MeV to that at 150 MeV) is:

$$760 \text{ mA} / 785 \text{ mA} = 0.96$$

This indicates that the accelerator is collimated well and all compensating and steering coils are functional.

#### Discussion

1. From the test results we know that the 250 MeV section can meet all major technical specifications as required in the design. The overall design has been proven to be feasible by testing the performance characteristics of various components. This is a good foundation for the testing of the 1.1/1.4 GeV electron LINAC.

2. In the second part of the 250 MeV section, microwave power is fed to four accelerating tubes from klystron K<sub>2</sub> through the use of an energy doubler. This part contributes 120 MeV to the energy. If the phase modulation coefficient is 0.95, the contribution of the 12 identical accelerating units behind the 250 MeV section is

$$120 \times 0.95 \times 12 = 1368 \text{ (MeV)}$$

Under the above conditions, if the electrons are accelerated, the energy obtained is

$$1.368 + 250 = 1.618 \text{ (GeV)}.$$

However, there is considerable work to ask 16 klystrons to operate stably at the same time to reach the required power output. There is some potential to gradually increase the power output of the klystron in order to raise the energy output of the accelerator. In the near future, the klystron output will be raised to 20 MW. However, there is not too much room to raise the energy of the accelerator.

3. An inspection of the inside of the accelerator revealed sparking marks at the end of the 30 MeV section and other high field areas. There are sparking marks in the positron converter. The vacuum in these areas needs to be improved and the power transmission needs to be rigorously controlled to avoid sparking.

#### References

1. R. B. Neal, ed. The Stanford Two Mile Accelerator (1968).
2. Summary of the Preliminary Design of Beijing 2.2/2.8 GeV Electron Positron Collider, IHEP (1982, 9).

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